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FIRST GET-TOGETHER OF RESEARCH AND INDUSTRY

December 20–21, 1965

Food, Agriculture, Agro-Industries, Fish, Meat, Sugar, Tea, Coffee, Industrial Crops, Oilseeds, Edible Oils

WORKING GROUP 6

COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH, NEW DELHI

39

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NEW DELHI

@ 1966
COUNCIL OF SCIENTIFIC & INDUSTRIAL RESEARCH
RAFI MARG, NEW DELHI, INDIA

Printed at Delhi Printers, 21 Daryaganj, Delhi 6

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S. C. GUPTA

Sugar Research in India

S. C. GUPTA
National Sugar Institute
Kanpur

The sugar industry is one of the world's principal industries. Countries favoured by nature for producing sugarcane or beet have given the highest importance to their sugar industries, for sugar is not only an essential article of food, but is also important as a strategic material.

India occupies an important position amongst the sugar producing countries of the world. During the last two decades or so she has established a sizable white sugar industry and also attained a fair measure of efficiency. It is now the second largest industry, next only to the textile industry. But if we must maintain our progress and compete in the world market we must increase our pace of scientific and technological development. Greater emphasis must be laid on research. How best this can be done is the question.

For research to be productive certain conditions must be fulfilled, viz. (i) the need for research must be fully appreciated, (ii) the problems of research must be clearly defined, (iii) the means for research must be adequate, and (iv) proper facilities must exist for the development of research. It would be useful to examine in what measure these conditions obtain in India in respect of sugar research.

Sugar research comprises the agricultural aspects and the technological aspects. The latter aspects may be considered here.

That for the sugar industry in India the need for research is imperative will be evident from the fact that our cost of production of sugar in general, leaves much to be desired. Although much of the high cost of production of sugar in India is due to the high cost of the raw material, nevertheless much can be done to improve our manufacturing technique in order to lower the cost of sugar. The by-products of the sugar industry are potential sources for a number of subsidiary industries. Research and development towards the utilization of the by-products can also help substantially in lowering the cost of production. In respect of improving the quality there is much more scope. Consumption trends show that the demand for better and still better quality of sugar is ever on the increase. Our industry is largely dependent upon foreign countries for machinery parts, instruments and chemicals. If we want our industry to thrive unhampered we must depend upon our own resources and bring our own genius to bear upon it. This can be done only when there is the urge to improve and the ambition to excel. But in India, there is not much of competition amongst sugar producers and as such the imperative need for research is not being fully appreciated.

The means for research are a good library, a well equipped laboratory and adequate staff. Technological research in sugar is being done in India mostly at the National Sugar Institute and partially in a few other laboratories, but the means at the disposal of those laboratories are not adequate.

In applied research, the results obtained in the laboratory are to be carried to practicality by applying technology to new ideas. The results of research have to go through a process of development before they begin to yield profits. But in this aspect the organization of our research lacks the most.

The above is an objective analysis of the situation. In order to improve the situation the industry should look ahead, put faith in research and cooperate with the research institutions in the latter's attempts to solve the problems of the industry in the proper way. It is therefore, for the industry to put forward its problems. The problems must continuously gravitate from the industry to the research laboratory. This can happen only when, the industry and its technical personnel develop an attitude of mind for achieving higher and higher efficiency through scientific research.

Once the industry begins to take interest in research, much of the deficiency and handicaps of the research institutions would be made good. Government on whom generally rests the responsibility for research in India, may not be able sufficiently to meet the costly demands of modern research. Industry has therefore to come forward and partly meet the needs of the research institutions. One of the ways in which industry can provide assistance is by offering scholarships and fellowships for research workers at the National Sugar Institute, Kanpur, and other research laboratories. This will help to alleviate the deficiency in respect of staff. The other way in which the industry's cooperation is indispensable is in respect of the development of the results of research. Though a few progressive sugar industrialists have generously spent large sums of money over the development of promising results of research, the general tendency is one of diffidence. It is the sad tale of our industrial research in India that the problems have to be conceived by the research workers themselves and the results obtained do not go out of the four walls of the laboratory. In fact there should be a regular traffic between the industry and the research laboratory in that the problems should start from the industry and go to the research laboratory and the results obtained in the laboratory should return to the industry for being worked to practicality and commercial possibility.

The formation of the National Research Development Corporation of India and the Development Councils for various industries has helped in enlisting active cooperation of the industries in the task of planning and development of research, but considerable effort is still needed in this direction.

Industrial research is a costly proposition and it is necessary for practical results to be obtained to invest on research much more than what is being spent at present.

The National Sugar Institute, which, as mentioned before, is the main sugar research institution of the country, has carried out research in the various engineering and technological aspects of sugar manufacture with such facilities as were available in respect of equipment and staff. A list

of some of the important subjects on which it has carried out research work and achieved significant results is given in Appendix 1. Now, though the Institute has got its own building and research facilities are being gradually augmented, there still remains considerable leeway to be made up in order to catch up with the standard of research work being done in other leading sugar producing countries of the world. The Thacker Committee which was appointed by the Government of India in 1961 for reviewing the working of the Institute and recommending the steps to be taken to make it fulfil the objectives for which it was established, felt that if the Institute was to be developed on modern lines to serve the needs of the second largest industry of the country, considerable development over and above that envisaged for the Third Plan period, would have to take place. The Committee made a number of recommendations of far reaching importance and drew up a plan costing Rs 280 lakhs. While recommending this expenditure the Committee observed that considering the financial returns the Government and the entrepreneurs obtain from this industry, expenditure of such magnitude should be considered to be very modest.

The Government of India provided a sum of Rs 100 lakhs for development of this Institute in the Third Five Year Plan. Out of this provision of Rs 100 lakhs, a sum of about Rs 23 lakhs was allocated for equipment and staff and rest for the construction of various ancillary buildings. The Working Group set up by the Government of India for assessing the requirements of the Institute in regard to research, manpower requirement and other activities of development in the Fourth Plan period has placed these requirements at Rs 193 lakhs as follows:

		Rs in lakhs
(i)	Apparatus, Equipment & Machinery	65.50
(ii)	Additional Staff	33.50
(iii)	Ad hoc Research Schemes	10.00
(iv)	Construction of Buildings & Sheds	69.50
(v)	Other items	14.50
	TOTAL	193.00

A list of problems on which research and investigational work is proposed to be carried out during the Fourth Plan period is given in Appendix 2.

Besides these problems, intensive researches need to be done on raw sugar production, which is entirely a new feature for this country, in order to enable us to produce it to foreign buyers specifications and make its cost of production as cheap as possible so as to export it at the minimum loss.

Research for developing techniques of sugar manufacture without sulphur is also needed because of the country's dependence on imported sulphur.

Research in machinery design is also very necessary, particularly in respect of some of the machinery still being imported like electrical and heavy engineering goods.

It is, however, felt that the resources of men and material at present available at the Institute are not commensurate with the volume of research work to be carried out and need to be augmented considerably. The yearly budget of this Institute amounts to about Rs 20 lakhs only which is very meagre as compared to other leading sugar producing countries of the world. The annual budget of the research organization of the Hawaiian Sugar Industry amounts to about two million dollars, whereas that of the Institute is only about Rs 8 lakhs.

Therefore, the National Sugar Institute, to be an effective instrument for the development of sugar industry of India, should be strengthened considerably with physical and financial resources and its activities so oriented as to make its outlook and aspirations, identical with those of the industry it seeks to serve.

APPENDIX 1

Some of the important subjects on which National Sugar Institute, Kanpur has carried out research work and achieved significant results

I. APPLIED RESEARCH

(a) *Milling*

1. Milling investigations relating to mill settings groovings, hydraulic loading, carrier speed, engine power, gearing ratios, etc.
2. Study of the comparative merits of steam turbine drive and steam engine drive for cane mill
3. Bacteriological assay of sugar factory products with special reference to sugar mill sanitation
4. Hydraulically loaded multiple roller crusher for Khandsari plants

(b) *Boilers*

1. Study of the types of boiler furnaces and their regulating devices
2. Clinker formation in boiler furnaces
3. Evolution of a furnace for burning wet bagasse of Khandsari factory

(c) *Clarification*

1. Semi-large scale trials of the
   (i) New technique of cane juice clarification
   (ii) Electrical method of cane juice clarification of Prof. D. N. Ghosh and its modifications
2. Use of vegetable gums and mucilages in cane juice clarification
3. Use of Versene in sugar industry
4. Demineralization of cane juice
5. Scale formation and their removal in sugar factories
6. Modification of processing technique to prevent colour development in carbonation sugars
7. Improved sulphitation process for Khandsari industry

(d) *Pan Boiling*

1. Resistance heating of massecuites

(e) *Storage of Sugar and Gur (Jaggery)*

1. Deterioration of sugar during storage and its prevention
2. Construction of sugar and gur godowns

(f) *Analysis and Control*

1. Apparatus for automatic weighment of bagasse
2. Automatic sugarcane juice sampling device
3. Sen's puncturing Needle for sampling juice from standing cane crop for determination of Refractometric Brix

(g) *Agricultural*

1. Assessment of manurial value of different types of molasses and press-mud and their effect on the chemical and physico-chemical transformation in different types of soils
2. Effect of spraying different doses of molasses on sugarcane foliage on the yield and quality of sugarcane crop
3. Application of hand refractometer in forecasting sugar recovery from standing sugarcane crop

(h) *Miscellaneous*

1. Treatment of sugar factory and distillery effluents
2. Examination of fermentation efficiencies on recycling of yeast
3. Studies on blackening and feathering of containers for packing fruits (micro-biological aspects)
4. Studies on anti-foam agents
5. Development of Mother Liquor Sampler

II. Basic Research

1. Studies on the changes in the composition of cane juice at different stages during the process of sugar manufacture when clarified by Dr Ghosh's electrical process
2. Studies on polysaccharides
3. Estimation of calcium in sugar house products
4. Study of the variation in aminoacids content of certain sugarcane varieties at different stages of plant growth and their effect on sugar recovery
5. Determination of pentosans in bagasse from various regions
6. Studies on the rate of crystallization of sugars
7. Studies on caramelization of sugar
8. Studies on the use of surfactants in sugar industry
9. A study of the ash constituents of different types of final molasses (Carbonation and Sulphitation) with a view to determine their exhaustibility
10. Studies on growth promoting factors in cane final molasses
11. Conductometric studies on molasses
12. Development of colour in sugars and measurement of colour in solid state
13. Effect of different doses of nitrogen and phosphoric acid in relation to different irrigation levels for assessment of manurial requirements, and their effect on clarificaton of cane juice
14. Effect of spraying gibberallic acid and different doses of molasses on sugarcane leaves on the quality of sugarcane crop

15. Studies on the synthesis of sucrose in sugarcane
16. Production of riboflavin from sucrose
17. Drug resistance in yeast
18. Studies on oxidation-reduction potential of micro-organisms used in industrial fermentation

III. Utilization of By-products

1. Manufacture of Furfural from bagasse
2. Study of quality characteristics of sugarcane wax
3. Survey of aconitic acid content of Indian molasses and its isolation
4. Utilization of spent wash from distilleries
5. Studies on citric acid fermentation of molasses
6. Utilization of carbonation press-mud
7. Production of cattle fodder from molasses

APPENDIX 2

Problems on which research & investigational work is proposed to be continued/started

I. Applied Research

(a) *Milling*

1. Extraction of sugar from sugarcane by diffusion process
2. Trial on beet diffusion and beet manufacture
3. Reduction of loss of sugar in bagasse during milling of sugarcane
4. Fundamental studies of the milling process with a view to improve on the existing method
5. Causes of roller shaft fracture

(b) *Boilers*

1. Fuel economy—Improved furnace designs
2. Clinker formation—Fundamental studies on combustion

(c) *Clarification*

1. Ion Exchange Process of cane juice demineralization
2. Studies on the settling characteristics of cane juice in order to improve the quality of clear juice
3. Studies on the filtering capacity of cane juice to improve the filtration rate and decrease the sugar loss in press-cake
4. Chemical Engineering problems related to Ion Exchange Process of cane juice demineralization

(d) *Pan Boiling and Curing*

1. Studies on the exhaustibility of molasses for reducing the loss of sugar
2. Studies on heat transfer in juice heaters, evaporators, pans, etc. in order to increase the efficiency of equipment
3. Studies on entertainment of sugar juice in evaporators with a view to decrease loss of sugar from the above cause

(e) *Storage of Sugar*

1. To investigate and suggest improved method of storage of sugar

(f) *Analysis and Control*

1. To study the variation of amino acids content of sugarcane juices of different varieties with respect to their quality and quantity at different periods of crushing season (November to April) and their effect on the process of clarification and sugar production
2. Studies on the changes in the composition of cane juices at different stages during the process of sugar manufacture when clarified by sulphitation or carbonation processes
3. To device a quick and economical method for the correct assessment of sugar value and to predict estimated recovery from standing sugarcane crop
4. Evolution of rapid methods for the estimation of different carbohydrates in the sugar house products
5. Study of inorganic non-sugars and their impact on sugar recovery during the process of clarification

(g) *Agricultural*

1. Studies on the composition of Indian sugarcane juices
2. Studies on the phenomenon of photosynthesis of sugar

(h) *Miscellaneous*

1. To study the suitability of burning limestone chips—a waste product of limestone quarries
2. Studies on High Polymer and Cellulose Chemistry
3. Treatment of sugar factory effluents
4. Production of riboflavin from sucrose
5. Studies for increasing the yield of alcohol and reduction of fuel consumption in distilleries
6. Studies on continuous alcoholic fermentation
7. Studies on the development of industries based on alcohol
8. Design of a suitable plant for the economic production of biogas from agricultural wastes
9. Studies on heat transfer from falling drops of water in air in order to improve open spray efficiency

II. UTILIZATION OF BY-PRODUCTS

1. Extraction of furfural from bagasse
2. Use of the factory waste molasses in the formation of sugar in sugarcane plant
3. Extraction of sugarcane wax from sulphitation press-mud and its modification in order to make it suitable for industrial use
4. Utilization of carbonation press-mud
5. Preparation of lactic acid and plastics from molasses
6. Production of cattle-fodder from molasses
7. Utilization of spent wash from the distilleries
8. Studies on citric fermentation
9. Production of butanol and acetone
10. Production of dextran from sugar molasses by Leuconostoc strains

III. Basic Research

1. Studies on the centrifugal separation of
   (a) suspended matter in raw juice and
   (b) suspended matter in press-mud
2. Studies on Sucro-Chemistry
3. Physico-chemical studies on clarification process to reduce CaO content, molasses formation, etc.
4. Study of the fundamental reactions taking place in sugar salt systems leading to the formation of mellassigenic complexes
5. Development of polarographic techniques for the determination of constituents of sugar house products
6. Employment of chromatic and radio tracer techniques for study of development of colour in sugar crystals
7. Examination by electron and X-ray diffraction studies, the nature and deterioration of sugar crystals at different periods of storage
8. Studies on the use of radio tracers for elucidation of various reactions occurring in clarification process
9. Use of radio-tracer technique and electron diffraction studies on the crystallization of sugar and structure of sugar crystals
10. Drug resistance in yeast
11. Studies on synthesis of sucrose in sugar plants
12. Studies on SO_2 gas juice interaction in sulphitation process of cane juice clarification to reduce sulphur consumption
13. Studies on Redox potentials dissolved oxygen in biological system and fermentation media. Kinetics of biological reactions in metabolism of carbohydrates and protein taking part in metabolic pathways of micro-organisms of industrial importance
14. Studies on the crystallization process of sugar in factory syrups and molasses to reduce the loss of sugar in final molasses

IV. Khandsari

1. Study of the existing designs of bullock-driven and power-driven crushers and furnaces
2. Study of the clarification process of cane juice for the manufacture of good quality Khandsari
3. Design of a furnace with a view of reduce fuel consumption and to incorporate heat saving devices
4. Design of a crusher for better extraction and with less power consumption
5. Study of the keeping quality of Khandsari with a view to reduce loss during storage

Problems in the Development of Fishing and Fish Processing Industry

A. N. BOSE
Central Institute of Fisheries Technology
Ernakulam

The importance of fishery as a source of relatively cheap protein food particularly for economically underdeveloped countries like ours where the *per capita* consumption of protein is much below the desired level, cannot be over-emphasized. Fishery has also proved to be good foreign-exchange earner due to increasing international trade in fish and fishery products and from this point of view also it is of particular importance to India. The total landings of fish in India amounted to 1.3 million tons in 1964. This catch will be considered to be small in consideration of the estimated fishery potentialities of the oceans and seas around India and her inland water areas. A target of annual catch of 1.8 million tons has been fixed to be reached at the end of the Fourth Plan period. Even this target, which will be considered to be rather modest, will require very efficient and planned harnessing of the scientific knowledge already available and that has to be created in designing, construction and operation of fishing crafts and gear and in developing the required type of handling, processing and transport facilities. The exploitation of fishery, particularly the marine, is controlled by the steps taken to increase the catch and in utilization of the catch. The paper has been divided in two parts: (i) dealing with problems of increasing the catch and (ii) dealing with the problems of handling, transport and processing of the catch for its best and most economic utilization.

Technological problems

Although large number of persons, over a million, in India are engaged in fishing as a profession, the fishing has been mainly restricted to inshore region and only indigenous traditional non-mechanized crafts have been used. For the purpose of exploiting a richer distant fishing grounds, mechanized boats were introduced in India about 15 years back, early mechanization being restricted only to putting in engines in the suitable indigenous boats for speedier movement. Prospects for good prawn fishery particularly along the Kerala coast led to the introduction of properly designed mechanized boats for speedier movement and for use of more economical and efficient fishing gear and methods. In the earlier days smaller fishing boats mainly below 30 ft in length required for the purpose were designed by the experts from foreign countries. But at present all the smaller boats up to the size of 50 ft have been designed and constructed by the Indian engineers. Larger fishing boats can also be designed and fabricated in India with the technical knowledge available in the country. As the fishing gear and

methods are changing and cost-reduction becoming more and more important, continued investigations on the design of the boats, propellers power take-off arrangements, mechanical accessories, etc. to increase the operational efficiency with respect to specific types of fishing are called for. Reduction in the cost of fishing boats is also important. Wooden fishing boats in India are made of Teak and in Southern States 'Aini' is used. Although 'Aini' is little cheaper than 'Teak' it is still quite costly. Taking into consideration the rapid obsolescence of the smaller wooden fishing boats, the use of other timbers, without sacrificing desired strength and durability should be considered. One such wood 'Venteak' which is less than half costly as 'Aini' has been found, after extensive trials, to be suitable as a boat building timber. Considering the rich forest wealth of India, it might be possible through continued search to find other timbers more suitable and less costly. Protection of wooden hulls against marine borers and foulers is important consideration in its construction and operation. Copper is at present generally used for sheathing of hull below the water-line. Due to scarcity in the supply of copper and necessity for import, other metals have been tried to replace copper. Aluminium (with 2 per cent or more magnesium) has been found to stand the marine conditions. It resists borer-attack and when coated with suitable anti-fouling paints remains free from foulers. The number of exposed dissimilar metals used in boat construction which will be in electrical contact through sea water, present quite often serious electro-chemical corrosion problems. Quite a few serious cases of corrosion of metallic sheathing, propeller, rudder-etc. with resultant damage to the boats have been reported. Studies of corrosion, electro-chemical and otherwise, of the different constructional materials on specified boats will be required to guide the selection of most suitable ones. In certain areas where boats are kept ashore frequently imported resin, Dammar Battu, is used for coating the hull. It has been shown that indigenously available resins can replace the imported ones effectively and other cheaper substitutes may also be found out.

In the field of fishing gear, the design of gear for specific type of fishery, choice for proper material for gear from the point of view of strength, work-ability, resistance of gear material to rot and weathering, etc. are important considerations. In use of gear generally the similar types of gear employed in other part of the world have been followed with suitable modifications. Ad hoc designs have also been evolved by trial and error. More extensive study of the gear not only from the point of view of fish behaviour, but also from hydrodynamic properties and operational requirements is necessary.

From what has been mentioned, it will be clear that for efficient operation of the fishing boats and gear, technical knowledge has to be built up through proper investigations and research simultaneously in a number of fields. Central Institute of Fisheries Technology now undertakes investigations on specified aspects of design and construction of fishing boats and gear including on materials of construction. However, other laboratories in India, which do not deal specifically with fishing boats and gears have better equipped laboratory for specific type investigations such as on tank-testing of boat-hulls, on testing of timber, on corrosion of metals, etc. While it will be desirable to deal with all problems directly related to designing and construction of fishing boats and gear in one laboratory in order to have a coordinated approach and speedier solution of immediate problems, there should be also collaboration between the different laboratories working in more specialized but related fields. In this way limited facilities and technical personnel with specialized knowledge can be pooled and utilized

for freeing the fishing industry from dependence on imported technical know-how and materials and make it self-reliant.

Fish processing

Processing may broadly cover all steps through which fish may pass after landing and before it reaches the ultimate consumer in the desired form. In India, the fish landed are mainly sold inside the country as fresh wet fish. Major portion of the frozen and canned fish produced in India is exported. Dried and cured fish is also exported although a good portion of it is consumed in the country. Main marine fish landing centres in India, being away from the most of the important consuming centres the importance of proper method of handling, transport and processing for distribution of fish cannot be over emphasized. The most poignant pointer to this is the fact that West Bengal and Assam have to import over Rs 6 crores worth of fish which nearly equals our earnings from export of fish and fishery products. Shortage of foodgrains also makes the maximum utilization of other food materials, particularly protein foods, imperative. The problems in the distribution over long distances under the atmospheric conditions prevailing in India are the shortage of ice, dearth of the necessary chain of refrigerated storage and transport and inadequate knowledge of the behaviour of particular species of fish under different methods of handling, storage and transport. Different types of bamboo baskets have been traditionally used in India for transport of fish over short or long distances. In some regions plywood boxes (old tea chests) have been used. It has been shown that even use of suitable liners, the rate of melting of ice can be significantly reduced. Putting easily detachable and recoverable insulating material slabs in plywood chests the storage life of iced fresh fish can be considerably increased. There is still a pressing need for developing economical and effective containers which reduce the rate of melting of ice, ensure even temperature distribution, will not cause any physical damage to the fish and will be light but of sufficient strength to stand the normal handling. Use of biostatic agents in ice or in pre-dip water has been shown to increase the storage life of fresh fish at the same time reducing the total requirement of ice for desired length of storage life. Treatment with permissible chemicals in solution or in gaseous form for preservation of fish in fresh state has also shown much promise. But most of the work of treatments with biostatics and similar chemicals have only been carried on limited laboratory scale and engineering and technological problems in their application in commercial transport and storage of fish varieties available in India have yet to be solved.

In the field of long time preservation, sun-drying is the age-old process, curing in the crude form has been used for long time but canning and freezing of fish on a commercial scale are more recent introductions. Although sun-drying and curing of fish have been widely practised in the maritime States of India for long time there has been little changes in the process followed since they were first used. At present these are non-uniform products of poor quality, low storage life and are generally unclean. The methods of production does not normally allow economic return to the fisherman, results in considerable loss of material and does not help much in supplementing the other food-resources of the country. In countries like India where the proper transport and storage facilities are not adequate, drying and curing should play important role in the proper distribution

of available protein foods, which are much in short supply. Improved methods have to satisfy the modern standards of hygienic production, has to cater to the taste and aesthetic sense of the larger group of population and has to manufacture the products at the economical prices in relation to the living standards in India. Investigations carried out in India have not up till now resulted in any process, suitable under Indian conditions, which has been extensively used commercially. Few plants of capacity of 2 tons of dried fish per day are proposed to be set up soon. These plants will utilize the available knowledge on hot-air dehydration of fish and will also indicate the directions for future development from the point of view of cost and product acceptability.

Canning and freezing of fish in India have generally been export-oriented. Almost the whole amounts of the canned and frozen prawns produced in the country are exported and they earned about Rs 4 crores equivalent of foreign exchange in 1964. Although canned sardines have got a good world market, the Indian product suffers from price disadvantage. Other varieties of fish canned in India are for internal market mainly for the armed forces. The products of canned and frozen prawn industry have to compete in the world markets with similar products from other countries with greater experience in producing these materials. Indian products have done well in this regard, being as they are the second largest in US import of processed prawns. Development of this industry to the extent as envisaged in the target for the Fourth Plan period, will depend on :

(i) availability of raw prawn not only in adequate quantity but also of required quality

(ii) assured supply of tin containers and packaging materials like waxed bounds, liners, etc. of the specified standards

(iii) availability and wider use of improved handling and processing equipment to increase speed and efficiency of production, reduce production losses and to prevent as far as possible the contamination due to manual handling

(iv) adequate provision for good water, electricity and chemicals required in processing for water purification and treatment, cleaning, etc.

The exploratory fishing being undertaken at present is expected to discover new and rich prawn grounds. Investigations will be necessary to find out condition for canning for the different species with reference to retention of material colour and flavour, tendency to sloughening, blackening, struvite formation, etc. during storage and pre-treatments, if any, necessary to prevent any undesirable changes in the fish tissue. In the field of containers we are still dependent to a large extent on imports. Tin plates used for cans in fish canning industry has till now been imported as the indigenously manufactured tin plate has not been considered to be suitable by the industry. Lacquers for coating are imported. Can-sealing compounds of required properties are now available in India. The various packing materials, such as waxed boards, fibre boards, waterproof liners, parchment paper, etc. of the quality required in export trade are imported. Regarding the machinery except some of the common ones, the rest are to be imported. Improved machinery are not often designed to handle the specific materials available in India or do not take into account some of the particular requirements to be met under the conditions of production in the country.

The above account will point out to the need of continued research for retaining and improving the competitive position in the world market of Indian canned and frozen prawn from the point of view of price, quality and presentation.

While trying to improve our position in the export of fishery products for which we have established foreign markets, diversification of the products will also be necessary for better utilization of the available raw materials and to ease dependence on particular markets. Product diversification may be directed to the manufacture of fishery products which are already in market but not produced in India, such as pastes, extracts, convenient foods, etc. or towards development of new products from the varieties of fish landed in India. This will also include manufacture of different by-products of fish-processing industry. In addition to well known by-products like fish-meal, fish-solubles, hydrolysates, other valuables like cholesterol, derivatives of nucleic acids, flavouring compounds can be obtained from waste fish tissue in processing factories. Manufacture of by-products will not only improve the economics of the industry but also contribute to the greater utilization of the valuable protein material.

Modern fishing and fish processing industries have recently started in India. Their development requires not only the application of the scientific and technological knowledge already available. A new and growing industry will continue to have many technological problems which will require sustained and intensive investigations. In India we have got the technical knowledge and facilities to work on and solve most of these problems. Main deficiency of the investigations so far carried out has been that they were mainly carried out under the restricted laboratory atmosphere and their adoption under actual industrial conditions have not been often investigated. Industry has not often found the results of laboratory investigations of much value to them because it finds difficult to evaluate them for commercial application in absence of the necessary data. There has also been undue bias of the industry towards imported know-how, materials and machineries. With mutual confidence in industry and research laboratories and close consultation and cooperation amongst the research laboratories, we should be able to solve the most if not all the technical problems of the industry and ensure its steady and increasing contribution in augmenting the food supply in the country and in earning foreign exchange.

Scientific Warehousing in Public Sector

P. M. THOMAS
Central Warehousing Corporation
New Delhi

With the main objectives of providing scientific storage and cheap credit facilities for agricultural and industrial commodities, the warehousing programme was established in the public sector in 1957, by an Act of the Parliament.

National loss in quality and quantity

There is an acute shortage of suitable storage accommodation for industrial and agricultural commodities in our country. It is estimated that 5 to 15 per cent by weight of the production is lost in defective storage due to moisture absorption, excessive heat, insects, mites, rodents, birds, etc. Even at 5 per cent the loss of the total production of cereals, millets, spices, oilseeds, jute, cotton, tobacco, leather, cement, fertilizers, textiles, etc. would come to over Rs 400 crores every year in India. In case of foodgrains, if the storage loss alone is avoided, there is hardly any food shortage for human requirements, and probably the whole food imports could be avoided.

Besides this quantitative loss, the qualitative loss due to biological and chemical changes like sprouting, moulding, development of acidity, gluten deterioration, loss in tensile strength of fibre, loss of industrial quality of other commodities, etc. is manifold.

Functions

As per the Warehousing Corporations Act, the functions of the Central Warehousing Corporation are :

(a) acquire and build godowns and warehouses at suitable places in India as it thinks fit

(b) run warehouses for storage of agricultural produce, seeds, manures, fertilizers, agricultural implements and notified commodities offered by individuals, cooperatives and other institutions

(c) arrange facilities for transport of agricultural produce, seeds, manures, fertilizers, agricultural implements and notified commodities

(d) subscribe to the share capital of the State Warehousing Corporations

(e) act as agent of the Government for the purposes of purchase, sale, storage and distribution of agricultural produce, seeds, manures, fertilizers, agricultural implements and notified commodities

(f) carryout such other functions as may be prescribed

Credit facilities

In the USA and Canada and other advanced countries, warehousing plays an important role in National economy. The importance of warehousing in providing scientific storage, in regulating the flow of goods to the market, in the evolution of proper grade standards, in the creation of instrument for obtaining cheap credit and in many other ways, has been well established. In the past, the producer had to sell his produce at uneconomic prices, especially at the time of the harvest or manufacture, to meet his immediate financial needs for want of scientific storage and credit facilities. The warehouses are issuing warehouse receipts to the depositors, who in turn pledge them to the banks and get advance to the extent of 75 per cent of the value of the stocks at a comparative low rate of interest. This advance helps the depositor to avoid 'distress sale' and wait for a better price.

Inspection, grading and weighment

It is a statutory obligation that all commodities offered for storage are examined and graded according to approved grade specifications. These are laid down in consultation with the Indian Standards Institution and the Agricultural Marketing Adviser to the Govt. of India. All commodities received in the warehouses are graded correctly, and weighed at the time of receipt and again at the time of issue.

Storage charges

The storage charges are kept as low as economically possible. The storage charge differs from commodity to commodity. It includes element of expenditure on godown rent, insurance, dunnage, establishment, disinfestation, depreciation, headquarter expenditure, etc. A 10 per cent rebate is specially allowed to encourage cooperative societies. All commodities received are insured against loss due to flood, fire and burglary, etc.

Storage structures

A basic requirement for scientific storage is suitably constructed structures. The custom is generally received either in bulk, bags or packages. The storage requirements are different from commodity to commodity and also from region to region depending upon climatic conditions. Warehousing, being a specialized agency to provide scientific storage, structures suitable for bulk and bag storage are designed and constructed. Masonry bagged storage structures, round and hexagonal bulk storage bins, specialized air-tight storage structures for commodities like jaggery, oilseeds, coffee, turmeric, pepper, ginger, cardamom, etc. are constructed in different parts of the country. For perishable commodities like vegetables, fruits, fish, etc. cold storage are also planned.

The Central Warehousing Corporation and the State Warehousing Corporations have so far 700 warehouses having a total capacity of 7.66 lakh tons. Much of the hired accommodation is being replaced by own construction. By the end of the Third Five Year plan, it is anticipated that over 8 lakh tons constructed godown accommodation will be made available to the Nation. As a crash programme to meet the urgent requirements of the Food Corporation of India and the State Governments, 5.15 lakh tonnes of godowns are being constructed in record time. The godowns constructed are moistureproof and rodentproof.

Scientific storage

Commodities received in the warehouses are graded, weighed and stored scientifically. Proper dunnage is provided. Commodities are stacked separately deposit-wise with proper alleyways for aeration, inspection and disinfestation. The height of the stack is regulated according to the requirements of the specific commodity. In case of infestation, the stocks are regularly dusted and sprayed with insecticides and fumigated with suitable fumigants.

Training. There is an acute shortage of trained personnel in warehousing and the Central Warehousing Corporation is holding All-India Warehousing Training Courses to meet the requirements of the Central Warehousing Corporation and the State Warehousing Corporations. In addition, limited number of basically qualified candidates from cooperatives and the trade are also trained. The training covers a wide range of subjects like marketing, grading, scientific storage, preservation, cooperation, price trends, business management, maintenance of accounts, administration, publicity, banking, insurance, first aid, fire fighting, etc. Since 1957, 11 such courses have been held and 827 candidates have been trained so far.

Benefits. Seven hundred warehouses are now serving as centres for scientific storage and they are daily demonstrating to the depositors the benefits of proper weighment grading, storage, preservation, etc. Every warehouse is provided with a laboratory and a specially trained and qualified personnel to lookafter grading and scientific preservation. Warehousing is playing an important role in Government's price stabilization policy, helping in the import and export, storage of specialized commodities, orderly marketing, training of personnel for warehousing and in addition to the much needed scientific godowns all over the country. The loss in storage in warehouses is practically brought down to negligible percentage. Even at the estimated 5 per cent saving on the commodity stored this year, in terms of money, the saving would work out to more than Rs 3,00,00,000.

Role of research & industry

For grading and preservation of agricultural and industrial commodities in warehouses, equipment and materials like moisture metres, gas masks, phostoxin, methyl bromide, ethylene dichloride carbon tetrachloride mixture, pyrethrin, etc. are being imported from foreign countries. Considerable drain on foreign exchange resources of the country is thus caused. By research, devices could be developed for the manufacture of equipment and materials indigenously which would save considerable foreign exchange. This would also bring down considerably the cost of the equipment and materials and also help the warehousing corporations to give service to the Nation at cheaper rates. Quoting an example, imported pyrethrum dust for dusting agricultural produce, like spices, oilseeds, oilcakes and milled products, etc. was once purchased from an Indian firm at the rate of Rs 2,800 per tonne, while pyrethrum indigenously grown and processed by the Government Drug Research Laboratory, Kashmir, could be obtained at the rate of Rs 800 per tonne.

By coordinating research and industry, necessary equipments and materials required for the construction of specialized warehouses and equipments and materials needed in running warehouses could be manufactured

indigenously. It could also be supplied at a very much cheap rate without any loss in quality of the services rendered.

It might be desirable to consider the possibility of manufacturing moisture metres, gas masks, ethylene dichloride carbon tetrachloride mixture, phostoxin and other insecticides and raticides that are daily required for preservation and storage of industrial and agricultural commodities.

Industry could profitably utilize the available warehousing facilities for storage of industrial products and raw materials. Credit could also be raised on the strength of the 'warehouse receipt' issued for the stocks deposited.

Oils and Fats : Short and Long-term Approaches

K. T. ACHAYA
Regional Research Laboratory
Hyderabad

The situation in India is one of a desperate shortage of fats of all types. Even the target for the Third Five Year Plan ending in 1966 is nowhere near realized : against the original Plan target of 29.3 lakh tonnes of oil from the five major sources (groundnut, mustard, sesame, linseed and castor), the actual production is likely to be about 20 lakh tonnes. In fact the target of 25.5 lakh tonnes suggested for 1971 is even lower than that originally fixed for 1966. Apart from this, another 8 lakh tonnes of oil are expected to be available from other sources and by imports. These paltry increases must be considered against the increase of about 60 million in population expected between 1966-71.

Coupled with this low production is the fantastically high prices of vegetable oils in India, twice the world price in many instances. This is a result of low yields, high overheads, and the speculative nature of the oilseeds market. Low production is primarily attributed to shallow soils; uneven rainfall distribution, since most of the oilseed crops are rain-fed; exhaustion of soil without rotation in cropping or use of fertilizers; low-plant population caused by low germination capacity; and insect damage to sown seed and seedlings. Thus, groundnut yields in India are about 630 lb./acre against 1800 lb. in Italy. Other contributory factors are given in Appendix 1.

In this paper will be considered both long and short-term approaches to this situation. The immediate question is the remedial measures to be taken up without delay. The suggestions shown in Appendix 2 are mostly those thoughtfully drawn up by members of the Oil Technologists' Association, Bombay Branch, following discussions with Dr Sadgopal of ISI in August 1965.

In Appendix 3, an effort is made to suggest lines of orientation of technological research in oils, fats and derived products at the various private and public technological research centres in the country based on the needs of today. This is set out in tabular form. The five major heads describe the various fields of research and between them cover all aspects of research and development work in this field. Under each head, the various possibilities have been classified into the four groups now receiving emphasis, viz. production, import substitution, export items and defence. Thus, under 'Raw Materials, Production', will be found various facets concerning a higher production of oilseeds and oils, in which technological research might be involved. Research possibilities are then suggested against each item. It is for individual technological laboratories to choose from this list items on

which they would like to work by reason of their interest or past experience.

An aspect which is vitally important, but has been covered only in passing under item 2.2, is the nature of the crash agricultural measures necessary to be taken if oilseed production is to be raised. It is expected that other papers from those better informed in this matter will fill up this important gap in the present communication.

APPENDIX 1

Factors Responsible for the Present Shortage

1.1 Failure to fulfil targets of production of oilseeds, which in turn is a result of several factors mostly connected with agricultural practices.

1.2 Hoarding of oilseeds and oils, and speculative practices.

1.3 Increased consumption of edible oils on account of better standards of living of the people and rise of population.

1.4 Use of edible oils, such as coconut oil, by the non-organized soap industry in soapmaking.

1.5 Indiscriminate export of groundnut oil to earn foreign exchange.

APPENDIX 2

Remedial Measures

Better and rational utilization of existing resources

2.1 Much greater crushing of cottonseed. Only about 20 per cent of the cottonseed grown in the country is now crushed, though most of the difficulties have been overcome. Equipment is also indigenously available. This is one of the few fat resources available readily and full use must be made of it in this crisis.

2.2 As an austerity measure for a short duration, soap manufacturers should be required to lower the T.F.M. content of laundry soaps to 40–45 per cent and use builders such as sodium carbonate and sodium silicate. The Indian Standards Institution should accept this as an interim grade for the emergency period. The increased quantity of soap thus produced with the same amount of oils will be enough to meet some of the present increase in soap consumption. Such measures were in force in UK and USA during war time. Use of edible oils such as coconut, groundnut and sesame for hair oils and hair preparations should be banned and manufacturers should be required to replace these with suitable grade of mineral oil, inedible oils such as castor oil, or their blends.

2.3 Available cottonseed and rice bran should be fully diverted for oil extraction and the extracted meal alone should be used for cattlefeed. Linseed oil and cottonseed soapstock should be encouraged as sources of oil in cattlefeed in place of the more valuable cottonseed, groundnut, sesame and coconut oils.

2.4 Cottonseed soapstock must be converted into acid oil as soon as it is produced at the refineries themselves so that usable fatty acids are not lost as oxidized fatty acids.

2.5 Soap manufacturers should be required to use about 5 per cent of castor oil in laundry soaps. This would release equivalent quantity of groundnut and coconut oils for edible purposes.

2.6 Food-grade solvents alone should be used for extraction of obigenous materials so that the solvent-extracted oil could be used for edible purposes.

2.7 Low oil-bearing oilseeds should be extracted directly with food-grade solvents.

2.8 High oil-bearing oilseeds such as groundnut should be expelled once and the resulting first pressure cakes should be directly extracted with food-grade solvents. This will require coordination between the present expelling and solvent extraction installations.

Use of food-grade solvents will make available increased quantities of oils for edible use.

2.9 The petroleum oil refineries should expedite manufacture of alkyl benzene for synthetic detergents. This will relieve pressure on the soaps and, therefore, indirectly on the edible oils.

Augmenting resources of oils

2.10 Efforts should be directed at increasing yield per acre of oilseeds by the use of improved strains and better cultivation practices. Some work has already been started on intensive cultivation of groundnut, but this should be extended to a much larger area and to many other oilseeds.

2.11 Plantation of oil-bearing palm should be started in the Andaman and Nicobar Islands which are in the same climatic belt as Malaysia and Indonesia. Palm oil is an excellent raw material for soap and fatty acids. Low f.f. a.-palm oil could be used for edible purposes also. Per acre of plantation, palm yields about 50 per cent more oil than coconut and three times as much as groundnut. This would save considerable foreign exchange.

2.12 Export of solvent-extracted oilcake (extractions) should be limited and a part must be used in cattle feed. This would improve nutrition of cattle and yield more butterfat.

2.13 Raising of goats in an organized and scientific manner will provide meat, hide and wool and also tallow which can be used in soap-making.

2.14 Utilizing slaughter-house wastes for producing tallow.

Packaging and transport

2.15 There is considerable loss and damage done to oilseeds and oils on account of their bad handling in harvesting and transport, use of improperly made bags, tins, drums, etc., and inadequate packaging. Producers, manufacturers and transport authorities ought to take greater care in packing and transporting oilseeds, oils and their derived products, so that there is least loss due to defective packaging and containers. Unnecessary transport and distribution over long distances should be avoided. It would be much better to distribute and market the material in the same region wherein it is produced.

2.16 Edible oil products like cooking oil, salad oil, vanaspati, etc. should be dispensed from central places similar to what is done at a petrol pump from where petroleum products are distributed from bulk lots. The consumers should be given a required quantity in their own re-usable containers so that tin plate which is in short supply could be more profitably used.

Tapping potential sources of oils

2.17 Only a portion of existing mahua trees in the States of Maharashtra, Gujarat, Madhya Pradesh, Bihar, Assam, Mysore and Madras is being utilized at present. Sustained efforts should be directed towards collecting more seeds and extracting oil. Mahua is a well-established fat and our only indigenous source of hard vegetable fat. Its flowers can be used as a source of sugar and the residue as cattlefeed. This would help to reduce the cost of the oil.

2.18 *Pisa* and *Pilu* (*khakan*) are excellent substitutes for coconut and palm oils for soap making. Although this has been known to us for the past few decades, we have allowed this excellent resource to go waste and incurred heavy foreign exchange expenditure to import coconut and palm oils for soap making. A crash programme should immediately be started to collect available seeds and also to replant on large scale at appropriate places. *Pisa* can be grown in hilly regions and *khakan* near deserts.

APPENDIX 3

Orientation of Technological Research in Oils, Fats and Derived Products

Field or area	Research possibility
RAW MATERIALS	
A. PRODUCTION	
(a) *Oilseeds*	
1. Emulsifiers, wetting agents for insecticides	Sulphated castor and other cheap oils, ethylene oxide condensates of castor oil, rice bran oil and split fatty acids
2. Water conservation	Fatty alcohols: economics of manufacture by sodium reduction and high-pressure hydrogenation
3. Storage	Design of simple storage silos, applicators for fumigants, storage of groundnut in shell
4. Harvesting machines	Design of harvesters for groundnuts, castor seed, mustard seed and linseed and of shellers for groundnuts and castor
5. Analytical facilities	Help breeding work of agricultural stations by offering help in analysis
6. Fertilizers	Examination of oilcakes of unusual seeds (e.g. mahua, karanja, etc.) as fertilizers
7. Insecticides	Extracting unusual principles from minor oilseeds for test as insecticides, synergists, etc.
(b) *Oils*	
1. Extraction efficiency	—
2. Storage	Process for manufacture of known high-grade anti-oxidants (BHA, BHT, PG), storage of unusual oils
3. New sources	Rice bran oil (difficulties), economics of collection of minor oils, upgrading minor oils (neem, kusum), upgrading soapstocks (groundnut, cottonseed)
4. Augmenting cottonseed oil and rice bran oil production	Utilization and upgrading of by-products
5. Safflower oil	Cultivation, breeding studies, pests, raising oil yield
6. Hard oils from other sources	Hardening liquid soapstocks, converting castor oil to a hard oil
7. Tung oil	Cultivation
B. IMPORT SUBSTITUTION	
1. For soyabean oil (cotton-seed oil)	Upgrading cottonseed soapstock
2. For tallow (mahua)	Economic process for decorticating mahua seed and refining mahua oil
3. For tung oil (natural, synthetic)	Utilization of jacaranda and calendula oils, synthetic conjugated oils, e.g. from castor oil or other oils
4. For coconut oil	Refining, etc. of khakan fat, degrading other oils to C_{12}–C_{14} products

Field or area	Research possibility
5. For palm kernel oil	As above
C. EXPORT ITEMS	
1. Products from castor oil, not oil itself	Castor alcohols, perfumes, surfactants, lubricants, sebacic acid and its esters, DCO fatty acids, new possibilities (estolides)
2. Do not export oilseeds, but crush in the country	—
D. DEFENCE	
1. Several of the above also apply	—

PROCESSING OR PILOT PLANTS AVAILABLE AT TECHNOLOGICAL LABORATORIES

A. PRODUCTION	
1. Use pilot plants fully as semi-commercial research and production units	General principles
2. Use expellers and solvent extraction units to produce, e.g. unusual oils which commercial processors will be unwilling to process	Mahua, neem, other non-edible oilseeds collected by the All-India Khadi Village Industries Board
3. Use fatty acid distillation units for production	Cottonseed soapstocks (even if uneconomic)
4. Continuous refining units, use regularly	Refining oils produced by the AIKVIB
B. IMPORT SUBSTITUTION	
1. Design of modern processing units by chemical engineers at laboratories on behalf of manufacturers of machinery.	
2. Fabrication of small units for industry where workshop facilities exist.	
C. DEFENCE	
1. Where possible use pilot plants, e.g. autoclaves, hydrogenation units, vacuum distillation units, etc. for production of defence items	Sabacic acid and dioctyl sebacate, undecylenic acid and heptaldehyde

BY-PRODUCTS

(oilcakes, hulls, linters, soapstocks)

A. PRODUCTION	
1. Improvements in production methods	Offer advice to production units
2. Cleaning methods for by-products	Possibilities of cleaning oilcakes, linters and soapstocks
3. Upgrading the quality	Castor oilcake, mahua oilcake

Field or area	Research possibility
B. Import substitution	
1. Protein imports	Substitutes from oilcakes of cottonseed, sesame, groundnut, etc.
2. Hulls and shells	Preparation of active carbons, hardboards, other imported products
3. Linters	Upgrading of linters and utilization in acetate, nitrate, etc. products
4. Lecithins	Indigenous sources, preparation of various grades, bleaching
5. Fatty acids	Splitting of fats under Indian conditions, fatty acids of unusual oils
C. Export items	
1. Upgrade quality of oilcakes	Preparation of high-grade edible flours, protein isolates
2. Products from low-grade oilcakes	Protein hydrolysates, water-soluble proteins, protein condensates as surfactants
3. Products from hulls and shells	As at B 2 above
4. Products from germs	Study of groundnut and maize germ oils
5. Products from linters	As at B 3 above
6. Products from gums, sludges, etc.	Nature, utilization, upgrading
D. Defence	
1. Fatty acids for rubber compounding	Hydrogenation of low-grade oils for use in place of groundnut oil

DERIVED AND SYNTHETIC PRODUCTS

(either derived from oils or products such as catalysts utilized in such derived products)

A. Production	
1. Technological difficulties	Closer liaison with research laboratories and manufacturers
2. Alternative or cheaper raw materials for edible use, soap, paints	Castor oil to a soapmaking oil, or paint oil, products from cashewnut shell liquid
B. Import substitution	
1. Hydrogenation catalysts—manufacture, substitutes, recovery and reactivation of nickel	Manufacture, substitutes, recovery and reactivation of nickel
2. Synthetic materials	Emulsifiers, wetting agents, detergents from cheap fat-based sources
3. Waxes for polishes, fruit preservation, water conservation	Acid-alcohol esters varying acid and alcohol components
4. Active carbons	From hulls and wastes (as at item IIIB2)
5. Active earths	Preparation of special grades now imported

Field or area	Research possibility
6. Special surface coatings	—
7. Pigments for paints	Study of indigenous sources, upgrading of these
8. Perfumes for soaps	—
C. EXPORT ITEMS	
1. Export finished products instead of oils, vanaspati, paints	Soaps, vanaspati, paints, syndets, waxes, active carbons, active earths
D. DEFENCE	
1. Fats and waxes for shoes, etc.—tallow, hard and soft polishing waxes, etc.	Tallow, tallow substitutes, hard and soft polishing waxes for leather, etc.
2. Special fat-based foods	Formulations, rancidity
3. Lubricants—blown castor oil, blown mustard oil, sebacic acid	Blown castor oil, blown
4. Special paints	Preparation from indigenous raw materials of primers, heat-resistant paints, camouflage paints, food-can lacquers

DESIGN AND FABRICATION OF EQUIPMENT

A. PRODUCTION	
1. Collaborate with manufacturers of machinery by offering modern technical designs with their collaboration	
B. IMPORT SUBSTITUTION	
1. Major imported items	Prepare list
2. Produce advanced design drawings of specific items	Decorticators, driers, corkers, expellers, refining units (batch and continuous), bleaching, deodorizing fatty acid distillation, paint machinery
3. Measuring and testing equipment	Prepare list
C. EXPORT ITEMS	
As above	
D. DEFENCE	
1. Reclaiming used lubricating oils	Design and fabrication unit

Meat Production, Consumption and Export

G. C. JUNEJA
Ministry of Food & Agriculture
New Delhi

Meat is an important article of human diet throughout the world. In India it is derived mainly from sheep and goats. Poultry, cattle, buffalo, pigs and to a small extent other species of animals also contribute towards meat production. As per estimates of the Directorate of Marketing and Inspection (1959), the total quantity of meat produced in the country is as under :

	Million lb.	Percentage
1. Cattle (beef)	214.6	19.6
2. Buffalo flesh	165.7	15.2
3. Sheep (mutton)	251.2	23.1
4. Goat meat	350.0	32.1
5. Pigs (pork, etc.)	52.9	4.9
6. Poultry meat	56.0	5.1
TOTAL	1090.4	100.0

According to available estimates there are 1278 slaughter houses in the country.

The actual production of meat would be much more since private slaughtering is also extensively practised. The total annual meat production of over 1,000 million pounds may be valued at about Rs 128 crores. The production of meat yields a number of edible and non-edible by-products. While all edible parts of carcasses are generally utilized for human consumption, there are a number of organs and glands which are particularly valuable for the manufacture of hormones and other pharmaceutical preparations which are mostly allowed to go waste.

Of all the meats, goat meat is much more popular. It is even preferred to mutton. The demand for beef and veal is declining with the imposition of ban on cattle slaughter since 1947. Buffalo flesh is the chief source of bovine flesh in the country for poorer sections of the people but being a dairy animal only those that are useless or unfit for production are available for slaughter. The consumption of bacon, ham and pork is gradually on the increase. Amongst the poultry development programmes, broiler production is now getting greater attention. Rearing of rabbits for meat and fur, at present, is of little significance. Wild animals, though substantial, do not offer much scope for the development of meat industry.

Though India has a very large livestock population, no specific efforts have been made in the past for breeding livestock with a view to augment meat supplies for human consumption. In our country quite a large section of the population is vegetarian. Even of those who are non-vegetarians, a large proportion, viz. the Hindus, are averse to consuming beef. Therefore, maintenance of livestock in India is primarily for other purposes, i.e. to supply draught, milk, wool, etc. Our cattle and sheep have not been specially developed for meat.

Further, a large scale meat industry is possible only in countries having a large *per capita* area of land which would enable the raising of stock on grazing and fodder and they are being finally finished/fattened on surplus grains. In India where the availability of land per head is only 0.91 acres, the raising of stock, specially for meat, is not a feasible proposition.

According to the balanced diet recommended by the Nutrition Advisory Committee (viz., 1 oz. per head per day) it is estimated that about 8449 million lb. of meat would be required to be produced annually in the country. Even on the assumption that about 50 per cent the population are vegetarian, the gap between availability and requirement is quite large.

Position and programmes for production of different classes of meat

Beef. As already mentioned, due to the prevailing strong sentiments against the slaughter of cattle, the scope for large-scale production of beef is limited. In 8 States there is complete ban on slaughter of cows, calves and useful bullocks. In five States there is partial ban. In the States of Orissa, Goa and Pondicherry, there is no legislation controlling slaughter of cattle.

Buffalo flesh is at present an important source of bovine flesh consumed in the country. As buffaloes are prized as dairy animals, they are also slaughtered only when they become uneconomical or unfit for production. These animals are also not bred and fed to become meat animals.

Sheep. The estimated population of 40 million sheep is also looked upon more as an important producer of 70 million lb. of wool annually rather than as a producer of meat. Therefore, the main objective under the sheep development programmes under the National Five Year Plans had been to produce more and better quality wool to meet the requirements of the country. However, some attempts to improve the sheep in the eastern and south-eastern region from the mutton point of view are also being made and mutton sheep are now being introduced in mixed farming round about large towns to increase the production of mutton for urban areas. The meat from sheep is generally a subsidiary product except in certain tracts in the South where the animals are mainly of the mutton type.

Goats. The goat population in 1961 was 60.86 million and goat meat constitutes 32 per cent of the total meat production in the country. But goats are generally not favoured animals due to the great damage they cause to vegetation. Thus the goat in India has to fend for itself. The Animal Husbandry proposals in the Third Plan do not also include any large programme for the development of goats.

Pigs. Pigs have been one of the important source of nutritious meat in other countries, particularly those producing a surplus of cereals. In India, organized efforts had not been made in the past for breeding quality

pigs. Towards the end of the Second Plan, a scheme was taken up for the setting up of four Regional Pig Breeding Stations-cum-Bacon Factories (U.P., A.P., W.B. and Maharashtra), pig breeding units and piggery development blocks in the rural areas. In addition to these, setting up of 4 bacon factories and large pig breeding farms have been sanctioned under the Special Development Programmes in the States of Bihar (Ranchi), Kerala (Edayar), Rajasthan (Alwar) and Punjab (Chandigarh). The factory at Haringhatta has since come into operation, while the projects in other States are in various stages of completion. In the Fourth Plan there is a proposal to set up 7 new bacon factories (4 in public sector and 3 in private sector), 7 large pig breeding farms with 100 breeding sows and 10 development blocks and 15 small pig breeding farms with 5 development blocks.

Over 55 per cent of the meat consumed in the country consists of goat and sheep meat but due to the limited availability of meat in general for local consumption there is little justification for allowing any large scale export of goat meat and mutton to foreign countries. As regards other meat animals, due to the imposition of ban on the slaughter of cattle in most of the States, only poor, old and useless cattle should be normally available for slaughter and meat from these animals may not come up to the standard acceptable in foreign countries. However, it appears such meat would be acceptable in the far eastern and middle-east countries. There is not, however, much objection to the slaughter of buffalo, even though the rules and regulations in the States prohibit slaughter of productive ones.

In view of the present enormous cattle population of the country, there is no doubt that some scope for building up an export trade in meat exists with a view to earning the much-needed foreign exchange, if there is no strong public sentiment against it.

The possibility of expanding the export trade in meat and other animal products has been receiving our attention for sometime past. Even though no special efforts have been made in the past to breed animals with the particular object of producing better quality meat in the country, we on the animal husbandry side are quite aware that we could build up a sizable export trade in meat and particularly in meat products with our large live-stock population. But the primary obstacle in the way is the lack of facilities for the hygienic production of meat and lack of an organization for its certification which would satisfy the health requirements and standards set up by some of the importing countries. The matter was also considered in detail by the Animal Husbandry Wing Meeting held in Bombay in 1959, which recommended that a separate Directorate should be set up in order to provide and supervise arrangements for proper veterinary certification. It was also realized at the same time that in order to give authenticated certificates, it would be necessary to ensure proper ante and post mortem examination of animals, hygienic slaughtering and processing, and provision of proper cold storage facilities.

Present position regarding inspection and certification of meat

The question of introducing a system of veterinary inspection and certification after due examination of animals tendered for slaughter has been receiving the attention of the Government. In fact, a set of model rules and regulations were drawn up by the Government of India many years ago and were forwarded to the States. This matter has also been under examination by the ISI and they have finalized standard rules and

regulations governing the ante and post mortem examination of animals for slaughter. What is difficult is the enforcement of these rules and regulations as slaughter houses are owned by local bodies. It will be apparent to any casual visitor to our slaughter houses that the existing slaughter houses including those in the larger cities are antiquated in design and ill-equipped, lacking conditions for proper examination and the hygienic handling of carcasses. Therefore, the first pre-requisite is to provide modern slaughter houses at least at selected exporting points so that meat is produced under good hygienic conditions.

Most of the advanced countries, while permitting import of meat and meat products into their countries, insist not only on proper certification but also want to make themselves sure regarding the nature of arrangements in force for the inspection and processing of meat and meat products in the exporting countries. Foreign countries also insist on legislation covering inspection and issue of certificate for export of meat and meat products. But some of the countries in the middle-east and the far east do not require any strict veterinary certificates. These countries have been accepting meat certified by any veterinary authority in the country. But quite a large consignment of beef, etc. has been rejected by countries like Egypt, because of the bad state in which it was received due to lack of proper refrigeration facilities in transit.

In order to facilitate the export of casings to Japan, this Ministry has drafted a veterinary health certificate which is acceptable to Japan. As required by that country, we have also authorized Directors and Deputy Directors of Veterinary Services and Principals of Veterinary Colleges to issue certificates.

It may also be mentioned that we do not have at present any legislation regulating the production and inspection of meat. If a Central Act or order is made, even then the enforcement of the rules might have to vest in the State Governments. The State Governments even now exercise certain powers in the regulation of slaughter houses through their local self-Government departments who pass on to municipal bodies, rules, regulations, etc. for their adoption. In order to ensure proper inspection and certification of livestock and livestock products, imported and exported, it has been proposed to have a Central Organization under the Ministry of Agriculture in the Fourth Plan for Animal Quarantine, Inspection and Certification.

Scheme for improvement of slaughter houses

The question of creating conditions conducive to hygienic production of meat of high standard and quality, both for local consumption and for export to foreign countries, has been considered many times. The question was also examined by the *ad hoc* committee on slaughter houses and meat inspection practices appointed by this Ministry as far back in 1955. One of the main recommendations of this Committee was that all such urban slaughter houses as have now fallen within or are very close to inhabited areas should be closed down and new slaughter houses designed on modern lines and provided fully with requisite arrangements and facilities for efficiently conducting the slaughtering, flaying, dressing and all other operations should be set up well away from inhabited areas. The Committee also recommended that necessary structural alterations and other improvements should be made in other existing slaughter houses. The recommen-

dations of this Committee were forwarded to the State Governments for implementation.

Earlier the services of an FAO expert on slaughter houses were also made available to the State Governments of Maharashtra, West Bengal and Madras and he had drawn up detailed blue-prints for setting up new slaughter houses in the cities of Calcutta, Bombay and Madras. A scheme has already been included under Animal Husbandry in the Third Five Year Plan for the improvement of slaughter houses and meat markets. The central pattern of financial assistance is 100 per cent loan. Seemingly it was not very attractive and as such the scheme has not made much headway during the current Plan. The scheme has again been included in the Fourth Plan and a more liberal plan of financial assistance has been suggested. Services of a slaughter house expert from UK has been obtained under the Colombo Plan Programme and he is being deputed to the States on demand. He is also preparing model sketches for various sizes of slaughter houses which would be made available to the interested parties. So far there has been some progress in respect of Bombay slaughter house only. Site has been selected, drawings finalized and tenders for supply of machinery and equipment selected for placing orders.

Scope for export of meat products

Frozen meat. Among the various types of meat, there is a great demand for frozen meat from other countries. However, due to the prevalence of diseases like rinderpest, and foot and mouth disease, meat from India will not be acceptable to some of the western countries. But there is a good market for frozen meat in the middle-east and the far eastern countries, mainly due to two reasons. Firstly, the method of slaughtering done in India is acceptable also to Muslim countries. The price also is another factor. However, the general question and policy to be adopted in respect of promotion of export of meat particularly beef will have to be decided at the highest level in view of prevailing public sentiments regarding slaughter of cows.

At present according to the export policy, the export of beef is freely allowed. But the past experience of some of the exporters of beef to Egypt, Hong Kong, etc. has been disappointing. In these cases the complaints mostly were not in regard to the veterinary health certification, but regarding the quality and the condition in which these were received at the other end. The meat had considerably deteriorated due to lack of adequate refrigeration facilities for the proper freezing of beef and its storage and in transit from the cold storages to the port. Therefore, it appears that if steps are taken to adequately strengthen cold storage and refrigeration facilities at some of the important export points, the exporters will be able to satisfy the interested parties abroad.

Canned meat. Most of the importing countries exempt canned meat products from the operation of their meat inspection regulations provided the products have been sterilized by heat and hermetically sealed. Such canned meat would be accepted even by the United States which prohibits import of fresh, chilled and frozen meat from countries where rinderpest, foot and mouth disease, etc. are prevalent. Even the UK Importation of Carcass and Animal Products Order, 1954, admits unconditionally from other countries certain products which include meat and canned meat which has been subjected to a process of cooking throughout

its whole substance so as to render it unnecessary for it to be further cooked before being used for human consumption. But the UK would like to assure itself that meat products including canned meat imported into that country were subjected to continuous supervision from the time of slaughtering to that of packing so as to ensure that there was no possibility of the use of meat not inspected or found unfit for human consumption.

As regards the type of tinned meat that could be exported, we might perhaps defer consideration of canning of beef for the present.

We are generally of the view that as far as possible, we need not support any large scale export of mutton and goat meat in view of the shortage of meat for local consumption in the country. However, the ISI has drafted specifications for mutton and goat meat canned in brine.

The third category of canned products where there is some scope for export is canned sausages and canned port products. The ISI has already drafted specifications on various products, viz. pork, bacon, sausages, canned pork products and canned sausages. At present there are only one or two institutions (the Dairy Farm, Aligarh; Essex Farm, Delhi) which are producing small quantities of these products for internal consumption in the country. When the new factories sanctioned under the Third Plan Crash Programme come into production, the scope for export of pork products will be enlarged.

Animal casings. Animal casings from India are usually accepted in the Scandinavian countries and in the east in Japan, Hong Kong, etc. Previously these countries required a veterinary health certificate covering these casings to provide for ante and post mortem examination; we could not ensure the same in view of the existing conditions of our slaughter houses and meat inspection practices. Fortunately, these countries have accepted for the present the modified certificate proposed by us. But we have been receiving repeated complaints from Japan regarding the quality of the casings exported from India. The Commerce and Industry Ministry had also noted that the promotion of export trade in casings would be affected if quality of the casings exported was not ensured. That Ministry had requested us to examine the possibility of introducing a system of quality grading and pre-shipment inspection of casings intended for export. The Agricultural Marketing and Inspection Directorate has now an organization for the quality grading and certification of casings for export, based on the standards finalized by Indian Standards Institution on animal casings.

Poultry meat. The availability of poultry meat in the country has been estimated to be 0.16 kg. per person per year by the end of the second Five Year Plan which is likely to increase to 0.32 kg. by 1966. The bulk of it comes from the surplus cockerels, culls and laying stock after their first or second year of laying.

In absence of a specialized poultry meat industry, live birds are sold and purchased in the trade channel and the price is determined on the basis of size and age. Cleaning and dressing of birds to make it ready to cook is done by the consumers themselves. Towards the end of the Third Plan, however, some of the Government and private poultry farms have introduced dressing and freezing facilities with a view to salvage the culls and surplus cockerels quickly. This has led to the introduction of frozen dressed birds into the market though the number is far short of the demand.

With rapid industrialization and urbanization, demand for poultry meat is fast increasing day by day and broiler farms have started to come up around important consumption centres. Since meat-line hybrid stock noted for rapid growth and efficient feed conversion are available in the country and broiler raising is a short term operation of only 10–12 weeks, such farms would have come up in very large numbers. But, high cost of cereals which forms a major part of the broiler ration acted as a strong inhibiting factor in this direction. However, with increasing popularity of hybrid maize cultivation in the country, it is hoped that a specialized chicken meat industry will grow up in the country in the very near future.

To encourage growth of such an industry, automatic poultry processing plants capable of handling large number of broilers per hour is very essential as the economic advantage will be lost if the broilers are not killed when they attain a particular weight. Equally important are facilities for holding and transporting the product under refrigerated conditions in order to carry it from a period of surplus production to the period of scarcity.

Steps have already been initiated by the Government to provide these facilities during the Third and Fourth Plan periods. A complete plant with required facilities is in the process of erection at Chandigarh. Required machineries for another plant at Poona are expected to arrive from abroad shortly. Besides, industrial licence has been granted to a private firm to set up a plant in Delhi. Thus, it is expected that before the end of the Third Plan, three poultry processing plants will have been set up in the country. During the Fourth Plan, it is proposed to set up 15 more plants in different parts of the country to give a boost to broiler production.

Broiler production has tremendous scope in the country both for internal consumption and export. Being a short-term operation, there is a quick turn-over of the capital invested and with availability of special meat lines of stock, it is now possible to obtain a live weight of 3 lb. or more in 10 weeks of age. Thus production of chicken meat can be increased within a very short period of time provided there is an assured supply of feed materials. The future of the industry appears bright and it can reasonably be hoped that a sizable requirement of meat in the country will be met from this source.

Summary and Recommendations

(i) Against an anticipated requirement of about 4,900 million lb., the total quantity of meat produced in the country is only a little over 1,000 million lb.

(ii) As over 55 per cent of the meat consumed in the country consists of goat and sheep meat, there is little scope for export of this meat in view of the shortage of meat within the country.

(iii) In view of the prevailing public sentiment against slaughter of cattle and export of beef and due to imposition of complete or partial ban on the slaughter of cattle in the various States, there is very little scope for obtaining good quality beef for export.

(iv) Any export promotion programme will have to be limited mostly to buffalo flesh, animal products such as sausages, pork and pork products, etc.

(v) In view of the present condition of our slaughter houses and the stringent veterinary health regulations required by advanced western countries, there is not much scope at present for exporting meat in any form to those countries.

(vi) There is scope for export of meat and meat products to countries in the middle east and the far east in view of the less stringent requirements of veterinary certifications, method of slaughtering practized in the country and the comparatively low price of meat.

(vii) There is good scope for export of animal casings provided quality is progressively improved.

(viii) The Government of India have authorized selection officers (Directors, Deputy Directors of Animal Husbandry and Principals of Veterinary Colleges) to issue veterinary health certificates for animal products intended for export.

(ix) A suitable veterinary certificate has been drafted and circulated for adoption for veterinary inspection of casings and this certificate has been approved by Japan.

(x) There has been frequent complaints regarding the quality of meat and meat products exported from India. In regard to meat (beef) the complaint was against the condition in which the commodity reached the importing country. This was mainly due to lack of adequate facilities for freezing, during storage and transport of meat.

(xi) Japan has been raising objections regarding the quality of casings exported from India.

(xii) The ISI has laid down specifications for animal casings. The standards prescribed not only cover aspects relating to quality of casings, but the requirements envisage procurement of these casings from slaughter houses where proper ante and post mortem inspection is carried out according to prescribed standards by the ISI. At present none of the slaughter houses in the country would be able to satisfy the latter standards.

(xiii) In order to promote export of casings quality grading of casings according to ISI specifications except for satisfying the requirements regarding the slaughter houses from where they are to be obtained, is being done by the Directorate of Agricultural Marketing.

(xiv) Casings manufacturers should be given liberal assistance for procurement of equipment and facilities for the proper processing, etc. of casings at the slaughter houses.

(xv) When once a policy decision has been taken regarding the export of meat in general and beef in particular, either special export slaughter houses might be built up in the public sector or the private exporting interests be encouraged to set up small slaughtering establishments under Government inspection and control and be provided with adequate refrigeration and cold storage facilities for production and export of frozen meat. Adequate foreign exchange will be necessary to modernize the slaughter houses at export points.

(xvi) Under the Piggery Development Scheme sponsored under the Third Five Year Plan and Crash Programme, it has been proposed to set up 8 bacon factories at Aligarh, Haringhata, Vijayawada, Bombay, Ranchi,

Edayar, Alwar and Chandigarh. Steps will be taken up to expedite completion of these bacon factories as already programmed so that a beginning can be made with export of pork and pork products as early as possible.

(xvii) The production of poultry meat is also very low in the country. Poultry production has been encouraged on a large scale under the successive Five Year Plans both for egg and meat production. Under the Third Five Year Plan, special emphasis for broiler production in the country was given for the first time and three poultry processing plants are expected to be completed before the end of the current Plan, at Chandigarh, Poona and Delhi. Fifteen more such plants have been proposed under the Fourth Plan.

Weedicides from Coal-tar Fractions

M.S. ANAND, C.S.B. NAIR, A.N. BASU & A. LAHIRI
Central Fuel Research Institute
Dhanbad

The problem of attaining self-sufficiency in food production in India depends on a number of factors among which the loss caused by weeds is quite considerable. It has been observed that the extent of damage by weeds could be as high as 70 to 80 per cent in some cases[1]. Even if we take a very conservative figure of 10 per cent for the loss of agricultural produces, the amount for our country would work out to be Rs 4,200 millions (for the principal cereals, pulses, oilseeds, cotton, sugarcane and chillies) for one year.

Thirty years ago very little knowledge was available to the farmer regarding plant growth regulating substances but the intervening period has seen the rapid development of the industry dealing with the manufacture of plant hormones resulting in enormous advances in agricultural practices.

Ever since weedicides were first introduced in India in 1947, considerable progress has been made to assess the efficiency of these chemicals for the destruction ofw eeds like Kans and Water hyacinth, to inhibit the sprouting of potatoes and onions in storage, to prevent the premature fall of apples, for increasing the yields from sugarcane and Hevea trees and to prevent infestation of potato tubers.

Weedicides now available in the country are imported and these are mainly :

2 : 4-D and salts	—	app. 100 tons
2 : 4 : 5-T	—	app. 3-5 tons
Dalapon	—	app. 4-6 tons
Raglon	—	900 litres
Gramoxone formulations	—	1,350 litres

and experimental quantities of 2 :4-DB, EPTAM, MCPA, Banvel-D, MOURON, DIURON, TCA, DEF and maleic hydrazide[2].

Recently Government of India approved (four firms) to manufacture weedicides, an annual combined production of which (2 :4-D and 2 :4 :5-T) will be about 1,200 tons.

Coal-tar as source for weedicides

Coal-tar being the parent source of organic chemicals, the possibility of developing weedicides from the various coal-tar fractions, particularly the

tar acids and the tar bases appears to be very encouraging. The tar acid fractions of coal-tar contains a number of compounds such as phenol, cresols, xylenols, alkylated phenols, indanols and higher boiling phenols. There is a good possibility that phenoxy acetic acids and their derivatives particularly the halogenated ones prepared from these components might be useful as weedicides with selective activity. The information available on the activity as growth promoters of the phenoxy acetic acids prepared from xylenols, methylethyl-phenols or indanols is scanty and inconclusive[3].

There is evidence of herbicidal activity among the di-nitro derivatives of the alkyl phenols[4].

Recent researches by Russian workers indicate that pyridine and quinoline bases are useful as plant growth stimulants[5]. No systematic work has yet been carried out on this class of compounds. Some of the plant growth regulating substances that could be prepared from coal-tar fractions are listed in the Appendix.

Experimental work at CFRI

Work has been in progress at the Central Fuel Research Institute on the possibilities of utilization of the tar acids fractions for the development of phenoxy acetic acid type compounds. Preliminary studies revealed that optimum condition even for the production of 2 :4-dichloro phenoxy acetic acid was not available from the published literature. Hence a study was initiated to standardize conditions for this preparation.

Results and discussion

Four methods were studied for the preparation of phenoxy acetic acid from phenol and the most promising one, viz. the condensation of phenol and chloroacetic acid was studied in greater detail. Though the maximum yield for this reaction, as reported by Joseph Vahala[6], should be over 90 per cent of theoretical, much lower results were obtained at CFRI. Sen (private communication) claimed 70-80 per cent yields by reacting sodium chloro acetate by sodium phenate, whereas only 52 per cent yield was obtained by following the same method (Table 1). By maintaining higher alkaline condition (pH 13) and changing the proportion of the reactants the yield could be raised to 82.3 per cent.

It appeared that the reaction was not complete in the first few hours. A continuous experiment was done in which the reactants were periodically removed and analysed. The results (Table 2) revealed that the maximum conversions (82-83 per cent) were obtained in 6-8 hrs. It was, however, found possible to increase the conversion to 86.44 per cent by addition of chloroacetic acid in further instalments.

Chlorination of phenoxy acetic acid

Having developed a reliable method for the preparation of phenoxy acetic acid, attention was directed to its chlorination in the 2 and 4 positions. Haskelberg[7] obtained 82 per cent of the 2 :4-dichloro derivative by the chlorination of phenoxy acetic acid with chlorine. Other workers[8,9] got much lower yields by this method and tried to make improvements without much success.

Table 1—Comparison of various methods of preparation of phenoxyacetic acid

Exp. No.	Reactants 1	Reactants 2	Mol. proportion $ClCH_2COOH$ PhOH	Temp. °C.	Time hr	Yield % phenoxyacetic acid on theoretical	Remarks
1.	Chloroacetic acid	Sodium phenolate	1.5 :1	98	1	36.50	Method recommended in "organic reagents for organic analysis" published by Hopkin & Williams Ltd.
2.	Chloroacetic acid	Sodium phenolate	1.25 :1	98	1	36.50	Method according to J.A.C.S., 53, 1931, 304
3.	Sodium chloroacetate	Sodium phenolate	1.25 :1	98	1	37.00	Sodium chloroacetate was prepared by reacting $ClCH_2COOH$ with Na_2CO_3
4.	Chloroacetic acid (in absolute alcohol)	Anhydrous sodium phenate	1.25 :1	98	1	Low yield	Upto condensation state, absolute alcohol was used as medium
5.	Sodium chloroacetate (anhydrous)	Anhydrous sodium phenate	1.25 :1	98	1	Low yield	Sodium chloroacetate was prepared by reacting $ClCH_2COOH$ with N_2CO_3. Absolute alcohol used as medium
6.	Chloroacetic acid	Sodium phenolate	1.25 :1	98	3	59.53	Three equal instalments of chloroacetic acid were added, each after 1 hr
7.	Chloroacetic acid	Sodium phenolate	1 :1.25	90	1	Low yield	*p*H 8·8—Method according to Joseph Vahala *et al.*[6]
8.	Sodium chloroacetic acid	Sodium phenolate	1 :1	90	3-4	48.97	
9.	Sodium chloroacetic acid	Sodium phenolate	1 :1	98	3-4	51.80	Method suggested by Dr A.B. Sen of Lucknow University

10.	Sodium chloroacetic acid	Sodium phenolate	1.25 :1	90	3-4	49.40	"
11.	Sodium chloroacetic acid	Sodium phenolate	1.25 :1	98	3-4	53.37	"
12.	Sodium chloroacetic acid	Sodium phenolate	1 :1	98	3	74.11	" Two further instalments of $ClCH_2COOH$ were added
13.	Sodium chloroacetic acid	Sodium phenolate	1.25 :1	98	4	68.41	" Two more instalments as in expt. No. 12
14.	Sodium chloroacetic acid	Sodium phenolate	1.25 :1	98	10	62.22	" No extra $ClCH_2COOH$
15.	Sodium chloroacetic acid	Sodium phenolate	1.25 :1	98	4	Low yield	" *p*H was strictly maintained at 8.8
16.	Sodium chloroacetate	Sodium phenate	1 : 1	98	10	74.35	Duration of the reaction increased
17.	Sodium chloroacetate	Sodium phenate	1.25 :1	98	14	86.44	(a) Hot reagents were mixed (b) More reaction time was given (c) One more instalment of $ClCH_2COOH$ was added after an initial heating of 4 hr
18.	Sodium chloroacetate	Sodium phenate	1.25 :1	90	14	78.61	"
19.	Sodium chloroacetate	Sodium phenate	1.25 :1	98	14	74.18	No extra amount of $ClCH_2COOH$ was added
20.	Sodium chloroacetate	Sodium phenate	1.25 :1	98	14	76.88	"

Table 2—Effect of reaction time on the yield of phenoxyacetic acid

Duration of heating (100°C.) (hr)	Percentage yield of phenoxyacetic acid on theoretical	Duration of heating (100°C.) (hr)	Percentage yield of phenoxyacetic acid on theoretical
1	73.99	6	82.28
2	75.90	8	83.45
3	81.96	10	82.81
4	81.66	14	83.45
5	81.91		

Following Haskelberg's method, 2 :4-D could be obtained with yields of 82 per cent on theoretical. The chlorination was first done at 20°C. and then at 60°C. ensuring that one mole of chlorine was fixed at each of these temperatures.

Separation of 2 :4-D from the reaction mixture was achieved by adopting a selective extraction procedure.

Conclusion

(1) A reliable method has been standardized for the preparation of phenoxy acetic acid.

(2) Conditions for the dichlorination of phenoxy acetic acid in the 2 and 4 positions have been worked out.

(3) A selective extraction procedure has been developed for the purification of 2 : 4-dichloro phenoxy acetic acid.

(4) Work on the preparation of phenoxy type compounds from higher boiling tar acids is in progress.

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APPENDIX

Weedicides that could be prepared from tar fractions

Dinitrophenol

4 : 6-Dinitro cresol (DNOC)

Pentachlorophenol (Dowicide-7)

Dinitro-O-Sec-butyl phenol (DNOSBP)

Dinitro-O-amyl phenol

2-Chlorophenoxy acetic acid

4-Chlorophenoxy acetic acid

2 :4-Dichlorophenoxy acetic acid

3 :4-Dichlorophenoxy acetic acid

2 :4 :5-Trichlorophenoxy acetic acid (Silvex)

2 :4-Dichloro-6-fluorophenoxy acetic acid

2 :4-Dichlorophenoxy ethyl benzoate (Sesin)

2 :4-Dichlorophenoxy propionic acid

2-Methyl-4-chlorophenoxy acetic acid MCP or MCPA

Sodium-2-(2, 4-Dichloro phenoxy) ethylene sulphate (Crag herbicide-1)

α-Naphthalene acetic acid (NAA)

2-Napthoxy acetic acid (NOA)

Indole acetic acid (IAA)

Indole butyric acid

2-β-Hydroxy ethyl pyridine

2-β-Hydroxy ethyl-4-methyl pyridine

2-Hydroxy methyl pyridine

1-Hydroxy-2-picoline

1-Hydroxy-2, 6-lutidine

1-Hydroxy isoquinoline

2-Carboxy pyridyl-3-glyoxylic acid

2-Bromo pyridine.

Export Oriented Commodities and the Industry: Tea, Coffee, Spices and Cashews

Central Food Technological Research Institute
Mysore

In view of the acute shortage of foreign exchange, there is an increasing awareness in the country to produce and export items which fetch foreign exchange. Among the main food items which fetch at present foreign exchange to the country are tea, coffee, cashews and spices. The tea and coffee industry as well as the cashew industry have been developed to an extent which can take readily to export of these commodities. However, in the case of spices, a lot of improvements and scope for larger exports are possible. In this article, a resume of the present position of these commodities and the need for development of the raw material, improvements in quality by better quality control procedures, better packaging, storage and utilization and development of derived products from the above commodities are being stressed.

Tea

Out of nearly 350 million kg. of total production, India is exporting tea to the tune of 224 million kg. at a value of nearly Rs 133 crores. Tea thus forms a major foreign exchange earner to the country. There is considerable scope for further improving the quality of tea produced in the country so that it will be possible for us to compete in quality with the teas produced from other countries. Among the various products which can find potential export market are instant tea and instant lemon tea. Steps are being taken at present to produce these items for necessary market surveys.

One of the important aspects in which considerable attention has to be given in the case of tea is to organize suitable operational studies in the industry so as to cut down the cost of production and improve the efficiency of operation at every stage. Improvements in the processing techniques are also necessary.

Coffee

Out of the production of 55,000 to 60,000 tonnes of coffee, we are exporting to the extent of 23,000 to 25,000 tonnes at a value of about Rs 9.5 to 10 crores. For the past two years, the production of coffee has been less for want of proper rain in the correct time. In spite of this we have been attempting to export about 20,000 tonnes for the past few years and we have been urging the International Coffee Council to increase our quota of export. With an assured quantity available for export, it will be possible for us to maintain this level in the years to come. The main problems in maintaining this level of export lie in proper quality control and grading. The coffee at present is being bulked at the various

Curing Works on the basis of appearance and similarity. No attempt is being made to blend coffees with almost the same cup quality. The Coffee Board is trying to get the services of an experienced coffee taster for the past two years and since no one was readily available, has decided to depute one of their officers to Europe for getting this training. With the introduction of proper cup tasting procedures prior to blending of coffee, it may be possible to export uniform quality coffee. It is also necessary for us to keep a record of the quality of coffee produced every year in the country so that the experience and the data built up will ultimately be useful in maintaining proper export quality in coffee. As an active member of the International Organization for Standardization, we are taking necessary steps to frame suitable specifications for coffee so that we may aim at standardization of definitions and specifications for the International trade.

It is also reported that there is a considerable demand for coffee containing cardamom in the Middle-East countries. Necessary work is now being carried out to produce suitable blends of coffee powder with cardamom as well as instant coffee with cardamom flavour. If the market surveys conducted on these products are successful, it will be possible to boost export of this item.

Spices

A seminar conducted on export of spices by the Indian Institute of Foreign Trade in collaboration with the Export Promotion Council in Bangalore last year highlighted the various problems and gave their conclusions and recommendations for the export of various spices. The production target and the export of major spices in the country are given in Table 1. In order to achieve the target for 1970-71, it is essential that a coordinated approach should be planned to help the industry and the producer with necessary technical advice. These aspects have been under study by one of the disciplines at CFTRI at present. This is a new unit started and requires considerable development in the coming years so as to tackle effectively the various problems facing the industry at present.

Table 1—Production target and export of major spices

(000 tonnes)

	Production 1962–63	Target 1970–71	Exports 1965–66	Exports Value crores 1965–66
Pepper	25·9	35·0	22	6·5
Cardamom	3·1	4·0	3·0	3·5
Ginger	17·5	27·0	8·0	2·5
Chillies	383·0	433·0	15	3·0
Turmeric	95·6	—	18	3·0
		TOTAL	66·0	18·5
		Target 1970–71	88·0	23·0

The problems of the industry can be broadly detailed under the following heads :

(i) Production of better varieties; suitable control of diseases at the plantation and help to the grower with necessary fertilizers and financial credit.

(ii) Handling, processing, grading and packaging of raw materials.

(iii) Production of essential ingredients from spices; creating market abroad for such derived products like oleoresins, essential oils, resonoids, etc.

Production

In recent years, there have been considerable fluctuations in the quantity of different varieties of spices produced in the country. The problems of improvement in the varieties, pest control measures to control disease, supply of fertilizers, etc. deserve considerable attention. In certain spices like cardamom, production is considerably affected by the attack of "Katte" disease and unless immediate and efficient methods of controlling this disease is suggested to the planters, it may be difficult to maintain the level of production in the country. This shortfall in production has considerably hoost the prices and with this high price, it may be difficult to export these commodities. The Indian Council of Agricultural Research has now taken up the research activities on the plantation of crops from the commodity committee and it is hoped that the research facility and the application of the results to the betterment of the crop will soon be undertaken in a comprehensive and coordinated manner. Similarly suitable chille varieties which have an appeal in foreign countries should be produced in the country and efforts should be made to export the same. In the case of ginger, there is a need for evolving fibreless varieties. Similar improvement in resistant strains of turmeric with high curcumin content is essential. Besides the above major spices, it is also necessary to increase the production of various minor spices which are at present imported into the country.

Processing of raw materials

Considerable improvements could be effected in the handling of raw material after harvest. One of the main drawback to the planters is the non-availability of suitable power to operate efficient mechanical driers for drying the spices. The drying problems of the spices should be studied in detail and suitable techniques, which can be applied under local conditions, should be developed in the interest of the industry. A recent prelimmary survey of the driers in use for cardamom drying, revealed that considerable improvement of the existing facility could be achieved with minor modifications. Such a survey is also necessary in the case of other spices. Once the spices are dried to a optimum moisture level and suitably graded, it is necessary to preserve them by suitable storage. The problems of storage may be broadly classified as deterioration in colour, deterioration due to insect infestation, deterioration due to loss or modification of the essential principles of spices, etc. Commodity-wise, these problems should be thoroughly studied and the available information on better storage facilities should be communicated and demonstrated to the planters on the spot.

Grading. Compulsory pre-shipment inspection and quality control have jointly been undertaken by the Spices Export Promotion Council and the

Directorate of Marketing and Inspection. The Indian Standards Institution with the help of the various research organizations like CFTRI and Directorate of Agricultural Marketing and Inspection have laid down suitable specifications. In spite of progress obtained so far, it is found that much more improvements in pre-cleaning and grading are essential. To improve the quality and maintain uniformity of the products which are being exported at present, sufficient chemical and technological data are lacking and in the coming years, efforts will be made to fill up this gap by the work of the Institute.

Production of essential ingredients from spices

Spices are natural products and as such, are liable to variations in flavour, quality and strength due to variations in climatic conditions. Changes in agronomical practices, harvest, subsequent handling and storage, influence the ultimate value of spices as flavour ingredient. In view of this, the industry and the users of spices are now becoming aware of the disadvantages and possible dangers of using raw commodities with low standards of purity and quality. The aromatic constituents and the other non-volatile components which are responsible for the flavour of spices can be extracted by suitable means to produce suitable products of uniform flavour strength. Although the whole spices are reasonably stable, the use of ground spices in large quantities show certain problems due to loss in flavour and aroma on storage. Hence in various countries, the use of essential oils, extractives of spices with true flavour and aroma of the natural spices are becoming more popular. Dry soluble spices which contain all the flavour constituents of the natural spices dispersed in sterile base where the disadvantages enumerated above are absent, are now available for the industry. They are well standardized being free from bacteria and enzymes, which may cause undesirable effects in the products in which they are used. The possibilities of producing such products in the country are immense. Some firms are already producing this in the country. They require lot of technical advice to improve the methods of extraction, improving the yields and also stabilizing them with suitable package. Work on the above directions has already been initiated in the Institute. The Institute will soon arrange a group discussion under the auspices of Spices Export Promotion Council to ascertain and understand the problems of the industry so that research projects could be geared to find solutions to actual problems.

Besides helping and improving the products at present produced by the industry, it is also necessary to set up suitable training centres where ideal methods of drying, grading, pre-cleaning, grinding, blending, processing and packaging of spices could be imparted. In this direction, the Institute can help the organization concerned.

Other possible export products

India has been the home of spices and in different parts of the country different preparations are at present being made with different combination of spices. It is just possible that some of these products may find an appeal in other countries provided suitable demonstrations and surveys are undertaken. A list of such items should be made along with the method of preparation so that the traditional methods of preparation and use of these spices can give a scope for popularizing these spices produced in the country. It may also be useful to develop products with various ingredients and spices to prepare instant preparations of indigenous taste. For example, it is

possible to prepare a bar containing tamarind, precooked dhals and various spices to prepare soup compositions. Considerable uniformity in quality could easily be achieved in such preparations. They give constant flavouring effect and are particularly easy to mix and get uniformly distributed throughout the product.

Unit packs

India has been exporting mainly bulk packs of spices all these years. These spices are marketed in unit packs in the importing countries. It is desirable that efforts should be made for the country to export the various spices in small consumer size unit packs. This will ensure proper uniformity and will also bring familiarity with Indian spices.

Cashews

Out of the total of 2,47,000 tonnes of raw cashews from East Africa, Brazil and India in 1964, about 50,995 tonnes have been exported as cashew kernels from the country. This fetch a return of Rs 214,147,000. It cannot be denied that we are importing from Africa almost 75 per cent of our export requirements. Even though India supplies nearly 95 per cent of the world's demand of cashew kernels, this pre-eminent position of the country's export trade may be affected when the producing countries start their own cashew processing factories in their own country. Thus, there is an urgent need for popularizing and increasing production of cashews in the country. The various problems of this industry were reviewed in a Seminar conducted in Sept. 1964 by the Indian Institute of Foreign Trade. Besides cashew kernels, it is also possible to produce other exportable articles from the cashew apple which at present is not being utilized completely. It is estimated that about 250,000 tonnes of cashew apples are at present wasted. These apples could be utilized for the production of juice concentrate, wine, liquors and candied products which will have unique export possibilities. The necessary technical know-how for the preparation of the above are available in the Institute. What is needed is an organization of the industry with suitable facilities for collection and transport of these perishable products to processing centres. Necessary encouragement for this should be given and suitable industry started on a cooperative basis for the production of the above items of exportable nature.

In order to bring down the cost of production, it may also be necessary to introduce necessary mechanization. A survey of the problems of this industry was made by the Institute and plans for instituting suitable projects for improvement in the processing of cashews are being planned.

Problems in packaging and insect control needs attention. Possibilities of export of roasted kernels in consumer size unit packs should be explored.

Modernization of Rice Milling Machinery and Practices in India

H.A.B. PARPIA & H.S.R. DESIKACHAR
Central Food Technological Research Institute
Mysore

Rice milling is the single largest food industry in India considering the amount of food it handles. Nearly 50 per cent of the total production of about 40 million tonnes of rice is handled by the mechanized sector while rest is processed by handpounding. The earliest mills were introduced into India from the continent at the turn of this century. The industry has made rapid advances since then and can cater completely to India's needs of rice milling machinery. It has become an established and viable industry. There are about 10 firms solely devoted to manufacture of large scale rice and dhal milling machinery. Besides these, several firms produce small sized 'Hullers'.

The large sized mills of about 1 tonne capacity per hour are completely automatic machines and comprise of a seed cleaner, paddy sheller, paddy separator, rice polisher and rice grader. Mechanical elevating equipment is also provided with the mills. There are about 1500 such automatic mills in the country. These are certainly better in operational efficiency than the 'Hullers' and can give an yield of 66-69 per cent of rice. These machines are generally copies of German design introduced into India about 30-40 years ago. While technological research has improved the efficiency of these automatic mills in other countries by modifications of design and improvement of precision of the milling equipments, the Indian design remains the same as when it was introduced years ago. Such improvements in design and precision as have been effected in other countries, if introduced into Indian mills, can increase the availability of rice from paddy by about 1 per cent and increase yields of head rice by 5-6 per cent.

Practicable programme of modernization

The Government of India has imported 6 rice mills of modern design from Japan and Germany and their superiority to Indian mills in certain respects has come to light. In any effort to modernize Indian milling machinery, it would be next to impossible for economic reasons and in national interest to import large number of machines of the modernized design to replace the existing type of machinery. Moreover, the installed capacity of the existing machines is nearly double that of its present working capacity since they are idle for nearly half the year round. The only practicable method of modernization is, therefore, to improve the efficiency of existing mills by suitable improvements, modifications or additions. A careful investigation of these aspects has been under study by us and in our opinion the following immediate programme of action, which is

practicable, can lead to maximum beneficial results with minimum expenditure and within the shortest period.

Improvement of existing seed cleaners

Nearly 1 per cent foreign material is present in paddy as normally obtained in rice mills. Seed cleaners now available in Indian mills are based only on a size separation principle and residual stones and grit not removed by mere size separation not only enhance wear and tear of the machinery but also reduce the quality of the resultant rice particularly that of the broken rice, and small rice screenings recovered from bran. Modern seed cleaners which combine size separation with pneumatic and gravity separation can remove efficiently almost all foreign matter from paddy. Such cleaners can be made in India itself. The CFTRI can help the manufacturers with designs for such machines suitable to Indian conditions. The introduction of these efficient cleaners can enhance the availability of rice by (i) making mill broken rice as edible as whole or head rice and (ii) enhancing utilization for edible purposes of rice germs and small rice screenings recovered by separation of rice bran which is now used only for stock feed.

Replacement of under-runner stone or emery shellers by rubber roller shellers

It is definitely established that brown rice shelled through rubber rollers undergoes less damage and has better storage quality than rice obtained by the conventional stone or emery shellers. The breakage during shelling of paddy in these under-runner shellers is nearly double that in rubber roller shellers. The total yield of brown rice is also 1 per cent more in the rubber shellers. The simple replacement of stone shellers by rubber roller shellers in Indian mills can be expected to bring in immediately a large amount of benefit conferred by the imported modern type of rice mills. Manufacture of such shellers does not appear to have been covered by patent rights in India and hence incentives should be provided to Indian rice mills to fabricate them in India itself. Enquiries from and discussions with Indian Rice Milling Machinery Manufacturers have shown that the rubber shellers can be made in the country. It is hoped that test trials with pilot machines fabricated by such entrepreneurs will pave the way for large scale manufacture and use of such mills as a normal routine in Indian rice mills.

Improvement of rice polishers

The hullers, polishing cones and the horizontal rice whiteners are the different types of machines that are used for the polishing of rice. Both the improved German Cone type design as well as the horizontal emery pearler of the Japanese design have been found to give minimum brokens during the polishing. These machines can also be introduced and fabricated in India in due course. The permissible degree of polishing for rice in India is at a low level of about 4 per cent. At this level of polishing differences between Indian and imported new type polishing machines does not seem to be large. Modifications to polishing machines in vogue can therefore be taken up later after the improvement to shellers is completed.

Other factors like new type paddy separators which although not leading to improved yield of rice but which may add to elegance of the process or efficiency of the working are also to be thought of in due course of time.

Substitute machines for 'Hullers'

Another important immediate action that is called for is to do away with the use of 'Hullers'. Although they are small machines serving the needs of small producers, they are highly wasteful machines since a large amount of rice is lost in the bran as flour and screenings. Banning the use of these 'Hullers' has been talked of from time to time. No definite decision has been taken because of the difficulty of suitable replacement. Either we should go all out for larger sized economic mills owned and operated co-operatively by producers in the rural parts or replace the 'Hullers' by sheller units only to produce brown rice. The brown rice can be processed further in large mills under careful conditions. For domestic use the 'Huller' can be used as a polisher for the brown rice prepared through the sheller. Sheller-Huller combinations may also be thought of for limited rural use.

Other improvements in rice milling practice in rice mills

Upkeep and maintenance of machines in top running conditions is essential to improve the efficiency of even the existing mills. Rice mill operators and mechanics need to be given proper training both in the theory and practice of rice milling. These can be organized jointly by the milling machinery manufacturers and the CFTRI. Proper inspection at regular intervals and a system of licensing would help greatly in enhancing the efficiency of the rice mills.

The use of proper machinery is only one of the important factors in improving the efficiency of the rice milling industry. The other important aspects are (1) procurement and proper storage of raw material in such conditions as to prevent loss by rodents, insects, etc. which not only cause physical quantitative loss but also lead to quality deterioration; (2) provision of rodent-proof flat, bin or silo storage facilities; (3) control of insect infestation by suitable fumigation techniques; (4) introduction of improved parboiling facilities to produce a high quality parboiled rice without sacrifice of quantitative yields.

Utilization of by-products

Yet another most important aspect which has not been fully taken advantage of is the utilization of by-products of the rice milling industry which can not only add to the economy of the industry but would also add to food resources of the country. Particular mention should be made of the necessity for introducing oil extraction from rice bran. While a few mills have started producing oil from bran, the potential for further expansion is very large. Diversion of even $\frac{1}{2}$ the total rice bran produced in the country which is handled by the mechanized sector for oil extraction can supply 0.2 million tonnes of extra oil to the country. If the quality of the bran is controlled by proper stabilization, the oil extracted can be a high grade edible oil.

One stumbling block in the large scale establishment of oil extraction units has been the small size of existing individual rice mills. It is necessary that the new units for oil extraction should be located in rice mills having a capacity of not less than 5 tonnes per hour. For utilizing bran from existing mills, a systematic collecting agency for mobilizing bran within a radius of about 10-20 miles should be introduced. The bran collected can be processed in a cooperative oil extraction centre.

Opportune time for modernization

In spite of the fact that rice milling industry is one of the oldest and the single largest food industry in the country, the status of the milling industry is at a very low level. It consists of a large number of inefficient, uneconomic mills working only to partial capacity. The impact of modern scientific and technological advances has not been felt by the industry. There is not even an awareness of the necessity for such improvements.

The setting up of the model rice mills has, however, been an eye opener to the rice millers. There is not only a keen sense of healthy competition among the indigenous manufacturers of milling machinery but also even among rice millers to improve the efficiency of their mills. Scientists, engineers and policy makers can all help together taking advantage of this enthusiasm among the rice millers and machinery manufacturers so that an era of modernization can be ushered in.

Economizing Sulphur in Sugar Manufacture

B. L. MITTAL
Dhampur Sugar Mills Ltd
Dhampur

Ways and means of reducing sulphur consumption in Indian sugar factories are discussed in detail in the light of operational experience in a sugar factory. A reduction of 40 per cent has been proved to be attainable in sulphitation factories. A substantial reduction of 90 per cent is shown to be possible through adoption of the two stage process of producing raw sugar from defecated juice and then refining in carbonation factories. Economics of conversion of sulphitation factories into raw sugar factories and carbonation ones into raw sugar refineries are also presented. Methods for eliminating altogether the use of sulphur, such as the Defeco-Melt-Crystallization process, ion exchange process are outlined.

Introduction

The sugar industry in India is estimated to consume about 25,000 tonnes of sulphur annually. This constitutes a little more than a twentieth of India's total requirements of sulphur met exclusively by imports. Whereas sulphur is an indispensable raw material for many industries such as sulphuric acid, fertilizers, pharmaceuticals, and defence production, it need not be quite so with sugar industry. At any rate, its consumption could be substantially reduced if not totally eliminated immediately. Also, it should be possible in the long run to develop sugar technology on such lines as to yield good quality sugar without resorting to sulphur. Possible lines of action to achieve the two objectives and the author's experience in this regard are discussed in this article.

Reduction of sulphur consumption

The average rate of sulphur consumption is 75 kg. per 100 tonnes of cane crushed (0.075 per cent on wt of cane) in the sulphitation process and 25 kg. (0.025 per cent on wt of cane) in carbonation process. Nearly 80 per cent of the cane in our country is processed by sulphitation. Further, even those factories based on carbonation are gradually switching over to sulphitation. When such is the case, the possible suggestion for reducing sulphur consumption, namely to convert all sulphitation factories into carbonation factories would not only be untenable but also hardly practical in view of the prohibitive investment the conversion would entail. Hence, it would rather be advisable to consider ways and means of reducing sulphur consumption in sulphitation plants.

Sulphur dioxide produced in the factory by burning sulphur is used for clarification of sugar juice by passing through the juice. Thus, economy

in sulphur might be possible at two stages, first where the sulphur is burnt, i.e. the furnaces, and then where SO_2 is consumed, generally known as sulphitation station in the sugar industry.

Economy in generation of SO_2[1]

Sulphur heated in air to 250°C. burns to form SO_2. Theoretically this combustion requires 3.95 cu. m. of air at 20°C. and atmospheric pressure. The reaction is exothermic, generating 2217 k.cal. heat per kg. of sulphur, which is quite sufficient to melt the sulphur and raise its temperature very high, depending on the rate of combustion. The liquid sulphur thus produced evaporates and the vapours react with the oxygen of the air to form SO_2. If the temperature rises beyond a certain limit, the molten sulphur would boil, making the rate of vaporization higher than the rate of oxidation. This means sublimation of sulphur which would result not only in loss of sulphur but also choking of the SO_2 gas pipe line. Hence, efficient control of production of SO_2 would require: (i) Control of the flame temperature inside the furnace, i.e. regulation of vapour pressure of the sulphur vapours in the air-gas mixture in such a way as to ensure complete combustion of sulphur, and (ii) Regulation of air supply to make oxygen available in sufficient quantities to oxidize all sulphur vapours. The former can be achieved by taking away externally part of the heat produced in the reaction. This is usually done by providing a water trough on top of the furnace. However, circulation of more cooling water than necessary in the trough would result in excessive lowering of the temperature of the vapours and consequently a lower rate of vaporization and longer time for oxidation of sulphur. This, besides adversely affecting the capacity of the burner, does not mitigate the risk of unoxidized sulphur passing out of the furnace. The author's experience has shown that a water temperature of 82°–85°C. in the trough effectively checks the sublimation of sulphur; also it is helpful to reduce the humidity of the air as far as possible since moisture in the air acts as a catalytic agent for the oxidation of SO_2 to SO_3 which is detrimental to sucrose in the juice.

Attention to the following design and operational details is essential in achieving efficiency in the burning of sulphur: (i) Design of the furnace so as to ensure thorough contact of air with the vapourized sulphur, and prevention of escape of the air (oxygen) before completing the oxidation; (ii) Adequately dimensioned air inlet and gas outlet; (iii) Proper charging device; and (iv) Proper inspection through suitably provided peep holes.

A furnace designed with an eye to these details has (i) proper baffles to guide the passage of air (the absence or even defective location of which results in high sulphur consumption), and (ii) a good tray area-furnace space ratio. This relationship is very important, in that the sulphur vapourized in a given time depends on the tray area whereas the time available for the oxidation reaction to be completed will depend on the furnace space. The tray area itself has to be related to the amount of SO_2 required, which in turn would depend on the rate of cane crushing. Use of more tray area than is actually needed, will invariably result in loss of SO_2 gas (or sulphur) as the rate of production of the gas will be higher than the rate of consumption.

The sulphur furnace in use in Dhampur Sugar Mills Ltd, is an example of a well designed furnace. It has two baffle plates which ensure passage

of all the air just over the surface of molten sulphur. It has 3 cu. ft of furnace space per sq. ft of tray area, which is considered good. Duration of reaction with 50 per cent excess air under a pressure of 5 psig comes to 30 sec. If the furnace space is reduced in relation to the tray area, the duration might become insufficient for complete oxidation. The tray area of the furnace is lesser than what it would have been, if arrived at on the customary basis, namely a sulphur burning rate of 2.27 kg./sq. ft of tray area/hr for a sulphur consumption rate of 0.1 per cent on wt of cane, assumed by most of the sugar factories in India; this has been possible because of a higher rate of sulphur burning obtained, i.e. 2.5 kg./sq. ft of tray area. Any further increase in the tray area, though likely to have involved higher consumption, would not have significantly improved juice clarification. This at once proves that the tray area used in sulphur furnaces should be determined very carefully to avoid waste of sulphur.

Economy in consumption of SO_2

Lime and sulphur dioxide are the usual clarificants used in sulphitation process. A portion of the lime added (*c.* 0.07 per cent on 100 per cent purity basis on wt of cane) in defecation is used up to neutralize the original acidity of the juice while the rest combines with SO_2 to form $CaSO_3$. Fifty-six parts of lime require 64 parts of SO or simply 32 parts of sulphur. Thus every part of CaO in excess of 0.07 per cent on cane wt requires 0.57 parts of sulphur, taking the absorption of SO_2 by the juice to be 100 per cent. On this basis, the sulphur requirement of lime added can be estimated. For instance, 0.10 per cent lime on cane wt would require 0.0171 (0.03×0.57) parts of sulphur, 0.26 per cent lime, 0.1083 (0.19×0.57) parts of sulphur and so on. Thus, it may be seen that addition of more lime than necessary leads to increased sulphur consumption. Hence it is essential to use the optimum quantity of lime to minimize the consumption of sulphur. The results obtained by the author during the 1963–64 and 1964–65 seasons have shown that reduced addition of lime not only effects substantial saving of sulphur but is also advantageous in subsequent operations, such as filtration, evaporation. In the first place, a lesser (optimum) dose of lime reduces the weight of filter cake since less $CaSO_3$ is formed. This not only increases the capacity of the filter station but also results in reduced loss of sugar in the filter cake, the figures being of the order of 0.08–0.09 per cent on cane weight as against the normal value of over 0.1 per cent for plate and frame type of filter presses. Secondly, it considerably reduces fouling of the tubes of the multiple effect evaporators as evidenced by the larger average duration of runs (period between two consecutive cleanings of a multiple effect evaporator), i.e. 33–36 days compared to the normal 10–20 days in sulphitation sugar factories. Contrary to the general belief that the quality of clarified juice is better with higher lime doses, an average rise in purity of the clarified juice by 0.75 units over that of the raw juice was obtained by the author with the lesser dose employed by him. With a lime (83–86 per cent pure) addition of 0.137 per cent on cane wt in the 1964–65 season, the filtrability of the mud was excellent, average filtration rate being 0.974 gal./sq. ft/hr and the cake formation rate was 1.24 lb./sq. ft/hr as against the normal value of 1.0 lb./sq. ft/hr.

The sulphur consumption in syrup sulphitation may be taken as 0.008–0.01 per cent on wt of cane under good conditions. It is likely that some SO_2 is wasted here due to incomplete absorption by the juice which may result from either poor absorbing quality of the juice or insufficient

duration of reaction, or both. The solubility of SO_2 in juice decreases rapidly with increasing temperature, which implies that absorption rate of SO_2 in juice will be higher at lower temperatures. Thus lower juice temperatures would make for economy in sulphur consumption. However, the general practice in sulphitation sugar factories is to heat the juice to 70°–75°C. before sulphitation. But by treating the juices at 50°–55°C., the author has obtained better results, not only in regard to reduced sulphur consumption but also in preserving reducing sugars intact, thus achieving better exhaustion of molasses. Any SO_2 that may still pass off in the stack gases may, however, be recovered through an absorption tower in the passage of the stack gases to the atmosphere using raw juice or the unsulphured syrup as the absorbent.

The results obtained by the author during the last two seasons, i. e. 1963–64 and 1964–65 are summarized below. It will be seen that sulphur consumption has been cut down by nearly 40 per cent of the usual figure for sulphitation process.

	1963–64	1964–65
Rate of cane crushing, tons/hr	101	103
Total tray area used, sq. ft	20	20
Average rate of sulphur consumption as % of cane crushed	0.051	0.045
Average rate of lime (83–86 per cent pure) consumption as % of cane crushed	0.134	0.137
Quantity of sulphur burnt per hr, kg.	51.51	46.35
Quantity of sulphur burnt per sq. ft. of tray area per hr, kg.	2.58	2.32

Total elimination/substantial reduction of sulphur consumption

Total elimination of sulphur in sugar production may be possible either through a process which can produce white sugar direct from cane, or through the two stage process consisting of manufacture of raw sugar direct from cane followed by refining in separate units, as adopted in most countries of the world (The latter accounts for nearly 80 per cent of the world production of cane sugar). The bentonite process, Saha process and Gosh's electrolytic process were efforts in this direction, but practical difficulties of one kind or the other have stood in the way of their commercial acceptance.

Amongst a few other processes that have been suggested for the direct production of white sugar from cane juice are the ion-exchange process and the Defeco-Melt-Crystallization process.

In the ion-exchange process, the raw juice after preliminary clarification by defection, is passed through beds of anion and cation exchange resins, whence demineralization of juice takes place and a very clear juice with a high purity is obtained. Sugar of very good quality can be expected with this process. However, this process involves imported ion-exchange resins and a big investment in plant and machinery. Further, its economics is yet to be established. As such, the chances of its adoption on commercial scale in India are yet remote.

The Defeco-Melt-Crystallization process consists of initial juice clarification by the defecation process and production of raw sugar as an intermediate product, followed by melting of the raw sugar and recrystallization of sucrose in the pans. Preliminary trials on this process carried out in one of the factories in North India are reported to have given sparkling white sugar of grade ISS plus 30. The process has yet to be tested on commercial scale and economics established. Its adoption would necessitate an increase in the capacity of boilers, pans, crystallizers, centrifugal stations, etc. by 20–25 per cent. The additional units which may have to be added in a sugar factory of capacity 1000 tons cane per day are as follows:

(i) One pan of 40 tons strike capacity
(ii) Two crystallizers of 45 tons holding capacity each
(iii) A few centrifugal machines
(iv) A few magma mixers, pumps, etc.
(v) A boiler of capacity 8000 lb. steam generation per hour.

Two stage production of white sugar

In this process, raw sugar is generally produced from juice clarified by defecation which involves no sulphur, and then refined by any one of the following processes available for the purpose:

Bone-char filtration—This process is now on the decline. Furthermore, it can not be adopted in India for sentimental and religious considerations of a majority of the population.

Vegetable carbon process—This process, employing vegetable carbons in place of bone-char, is much simpler and can be usefully adopted in India. Its economics is to be studied.

Deionization process—Similar to demineralization of the juice by deionization, this process is quite promising for the future when ion-exchange resins will be manufactured within the country on a commercial scale.

Carbonation process—Almost similar to juice clarification, this is a standard practice in refineries in UK, Australia and South Africa besides a few other countries. In this process, carbonation is carried out in two stages and the final neutralization of alkalinity of the second carbonated liquor is done by sulphitation. This will involve a sulphur consumption of about 0.07 per cent on raw sugar wt, which works out to about 10 per cent of the present total sulphur consumption in Indian sugar industry. Consumption of this sulphur can not possibly be eliminated for the present though further investigations may help in ultimately doing away with the use of sulphur in this process also.

Adoption of the two stage process would require sulphitation factories to be turned into raw sugar houses. This changeover, besides neither involving any capital investment nor any significant modification in plant and equipment, would offer the following advantages:

Increased capacity—The capacity of boilers and most of the units of the boiling house would increase by 20–25 per cent. It would, therefore, be possible to run the mills at the maximum rate. Thus, the cane-crushing capacity of the factories will increase by 10–25 per cent, depending upon the capability of the milling tandem (factories with smaller mill capacity may however be required to expand capacity by adding one or two mills in the train or by increasing the speed of rotation of the rollers).

Savings in chemicals—Apart from a net saving of about 25,000 tonnes of sulphur worth nearly Rs 5 million in foreign exchange, about 0.1 million tonnes of good quality limestone would be saved, which can be utilized in other industries. Savings in other chemicals may be taken as 0.2 million kg. of hydrosulphite of soda, 250 tonnes of caustic soda, 2,500 kg. of soda ash, etc. Savings in filter cloth (in factories still using filter presses) would amount to 33 per cent.

Increased sucrose recovery—Recovery of sucrose may be considered to be higher to the equivalent of about 0.05 per cent cane since undetermined losses in the process are very low. Inversion losses of sucrose are almost negligible due to favourable conditions to be obtained throughout the process.

Decreased depreciation—Since defecation process juice is not generally acidic, the wear and tear of the plant and machinery is considerably low, perhaps less by 50 per cent.

Saving in bagasse consumption—Steam consumption in raw sugar factories being less by 7-10 per cent equivalent of the cane than that of sulphitation factories, bagasse savings of 5 per cent equivalent of cane may be expected on an average. This works out at 1.5 million tonnes of bagasse, a sizable quantity that could be diverted for paper and board manufacture.

Utilization of waste molasses—Unlike the waste molasses of the sulphitation sugar factories, which is considered unsuitable as cattle feed, the waste molasses from raw sugar process can be usefully fed to cattle as is done in other countries. This should indirectly save a considerable quantity of gur now being consumed by cattle.

Saving in labour—A saving of about 40 workmen per factory can be expected.

The economics of conversion of a sulphitation factory of capacity 1,000 tons cane per day into raw sugar factory may be seen from the comparative figures for the two presented in Table 1.

Changeover the two stage process would, however, necessitates light modifications in the case of carbonization factories to make them function as raw sugar refineries. The milling plant and about 80 per cent of the boiler capacity of the carbonation factories that would become idle on this account can be used in building up new raw sugar factories. A few new big refineries will have to be built in South and western India where carbonation factories do not exist at present. The existing carbonation factories have an installed capacity of 1.5 million tons of refined sugar per annum. Thus additional refining capacity of about 2 million tons sugar will have to be established. Until such time the refineries are set up, the South Indian sugar factories may produce defecation sugar with complete remelting of second and third massecuite sugars and begging only first massecuite sugar after heavy washing in centrifugal machines. In this way sugar of ISS 28 grade might be produced.

An approximate estimate of the economics of refining raw sugar at the rate of 200 tons/day in a carbonation factory of 2000 tons cane/day capacity is given in Table 2.

Part of the expenses for refining the 63,000 tons of raw sugar could be met from the savings resulting from raw sugar products by defecation, which works out to Rs 22,60,000 (5,65,000 × 4, Table 1). Hence the actual cost of refining would work out to Rs 5,95,450 (28,55,450—22,60,000) or

Table 1—Economics of conversion of a 1000 ton cane per day sulphitation factory into raw sugar factory

	Cost (Rs) for		Savings	
	Sulphitation factory	Raw sugar factory	Quantity	Value (Rs)
Cane crushed per season, tons	1,50,000	1,50,000	—	—
Average daily crushing, tons	1,000	1,180	—	—
Number of days for season	150	127	23	40,000
Sulphur, tons	110	—	110	55,000
Lime, tons	300	100	200	20,000
Hydrosulphite of soda, caustic soda, soda ash, etc.				7,500
Filter cloth, sq.m.	5,000	3,300	1,700	6,500
Recovery of sugar (100 Pol)	10·0	—	—	—
Recovery of raw sugar (98.0 Pol)	—	10·37	—	—
Net gain is recovery of equivalent sucrose, tons	—	—	75	65,000
Bagasse consumption, tons	4,20,000	34,500	7,500	1,50,000
Labour, man days			6,000	21,000
Wear and tear				2,00,000
			TOTAL	5,65,000

Table 2—Economics of refining raw sugar in carbonation factory

(Basis 200 tons refined sugar/day)

	Basis	Quantity per annum	Rate (Rs)	Cost (Rs)
Production of refined sugar, tons	200/day	60,840	—	—
Raw sugar capacity, tons	2,100/day	63,000	—	—
Wage bill, Rs	80,000/month	9,60,000	—	9,60,000
Limestone, tons	5% on raw sugar	3,150	40/ton	1,26,000
Coke, tons	0·5% on raw sugar	315	90/ton	28,350
Sulphur, tons	0·07% on raw sugar	44.1	500/ton	22,050
Filter cloth, sq.m.	0·1 sq.m/ton raw	6,300	3·50/sq.m	22,050
Steam, tons	100% raw	63,000	9·0/ton	5,67,000
Transport charges of raw sugar, Rs	10/ton	6,30,000	—	6,30,000
Other stores and miscellaneous expenditure	—	—	—	1,00,000
Wear & tear of machinery	—	—	—	4,00,000
			TOTAL	28,55,450

say Rs 6,00,000 for 60,840 tonnes, i.e. Rs 10 per ton of refined sugar. The quality of refined sugar should be much better than that of sulphitation white sugar. Considering this, the extra cost of Rs 10 per ton of refined sugar would appear reasonable.

Estimated recovery of refined sugar by the two stage process can be expected to be slightly more, i.e. 0.15 per cent on cane wt than that by the sulphitaton process. This is so because less of Pol in raw sugar manufacture is less by 0.05 per cent.

Conclusion

It should be clear from the foregoing discussion that there is scope for reducing sulphur consumption in sulphitation process, and that a 90 per cent reduction of sulphur consumption is possible by the adoption of the two stage process of first manufacturing raw sugar and then refining it by carbonation.

Acknowledgment

The author wishes to thank Shri V.K. Goel, Director, and Shri S.R. Agarwal, Chief Executive Officer of the Dhampur Sugar Mills Ltd, for their interest in the work.

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Vegetable Proteins for Substitution and Supplementation of Dairy Products

M.R. CHANDRASEKHARA
Central Food Technological Research Institute
Mysore

Dairy production in India

The production of fluid milk in India was 22 million tons in 1961 and it was estimated that the production would be of the order of 25 million tons at the end of the Third Five Year Plan period. This increase of 13 per cent in the total available supply of milk would mean only an additional supply of $\frac{1}{2}$oz. per capita over the existing level of $5\frac{1}{2}$ oz. per capita daily. This is obviously very much short of the recommended allowances of 10 oz. per capita daily.

Table 1 summarizes the comparative data on the production and consumption of milk in some countries of the world. It is clear that India though one of the major milk producing countries is still far from being adequate in the production of milk to suit the demand.

The development of dairy industry in the country has received considerable attention during the past decade and several milk processing plants have been set up in the country; but it is a fact that almost all the new milk plants are working at very low capacity. There are many reasons for this.

It has been estimated that for providing 10 oz. of milk per capita per day the annual production should be of the order of 45 million metric tons, nearly twice the present production. Whyte and Mathur[1] have computed that for a production of 80 million litres per day (29.2 m. tons/annum) of milk (6 oz. per capita) the concentrates required would be of the order of 89.6 million tons, at a performance level of 5000 litres milk per cow per lactation. Even at a fairly high performance level of 1500 litres of milk per cow per lactation which may be possible under better breeding programmes the requirement would be 42.64 million tons. At present the availability of the concentrates (of which one-fifth is oilseed cake) is only 13.76 million tons representing a deficit of 71.2 per cent. Thus there is a wide gap to be bridged before we can provide the concentrates necessary for obtaining the milk to provide the minimum requirements of 10 oz. of milk per capita. This is only one aspect. There are the other related aspects of providing enough land, water and fertilizers for the cultivation of concentrates, of breeding and upgrading of cattle, of veterinary facilities and provision of sanitary procurement and transportation of milk. Each one is a major problem and requires considerable effort and resources for solving.

But one conclusion is obvious and that is that at the present time and for some more time to come we will not be in a position to produce much

Table 1—Production and consumption of milk in some countries

Country	Animal	Production × 1000 tons	No. of animal × 1000	Yield per cow kg./annum	Net food supply from milk per caput kg.		
					As fat	As protein	As calories
Australia	Cow	6,768	18,033	2,120	7	7	346
Ceylon	Cow	95	1,326	—	1	1	39
	Buffalo	30	—	—			
Denmark	Cow	5,355	2,062	3,640	9	9	379
India	Cow	8,180	2,26,809[1]	250[1]	3	2	108
	Buffalo	10,976		500[1]			
	Goats	562					
New Zealand	Cow	5,413	6,598	2,740	11	11	570
Pakistan	Cow	2,662	24,064	420	2	2	89
	Buffalo	2,920	—	—			
	Goat	759	—	—			
UK	Cow	13,036	2,763	3,010			
USA	Cow	57,119	19,167	3,340	8	8	397

more milk than what is now available. It is against this background that we have to judge the efforts of utilizing vegetable proteins as substitutes and supplements to milk.

Vegetable protein in infant foods

The use of soya milk and curd has been in vogue in China and South Eastern countries. In Indonesia a spray dried milk substitute has been produced under the name of '*Saridale*' from soya and sesame. Several spray dried soya dietetic preparations are available in America for use of children who are allergic to milk.

Extensive work on the value of soya and groundnut milk as supplements to dietaries has been done in India[2]. Since these were based solely on vegetable sources and were not dry preparations, there was difficulty in popularizing these. In view of these shortcomings recent efforts at CFTRI were focussed on spray dried infant foods based on soya flour and groundnut protein isolate[3]. Considerable work on the preparation, nutritive value and use in infant feeding of an infant food based on groundnut protein isolate and skim milk powder has been reported earlier[4, 5]. The method of production of this food required the use of groundnut protein isolate and dextrimaltose, both of which have to be separately prepared. In order to overcome this, groundnut flour was used along with barley malt and wheat to hydrolyse the starch in the groundnut flour and also simultaneously provide malt extract to the product (Flowsheet 1). The resulting spray dried infant food has been tested with animals and found to be as nutritious as milk food prepared from buffalo milk when fortified with methionine or when fed at 15 per cent level of protein, which is the usual level at which infant foods are fed to babies (Tables 2 and 3). In this infant food the milk solids derived from animal milk constitute only 26 per cent while its nutritive value is almost the same as that of milk.

At present the country is producing about 5,000 tons of infant foods but the demand has been placed 25,000 tons. The shortage of production as compared to the demand is essentially due to the shortage of milk. The scarcity of infant food in the market has even given rise to a flourishing black market. If this type of infant food based on groundnut flour and containing only one-fourth its weight of milk solids is manufactured in the country it could supplement the milk based infant foods to a great extent and could be made available to a much larger section of the population. Preliminary cost calculation has shown that its cost of production would be half that of infant food based entirely on milk.

Table 2—Composition of the infant food based on peanut flour

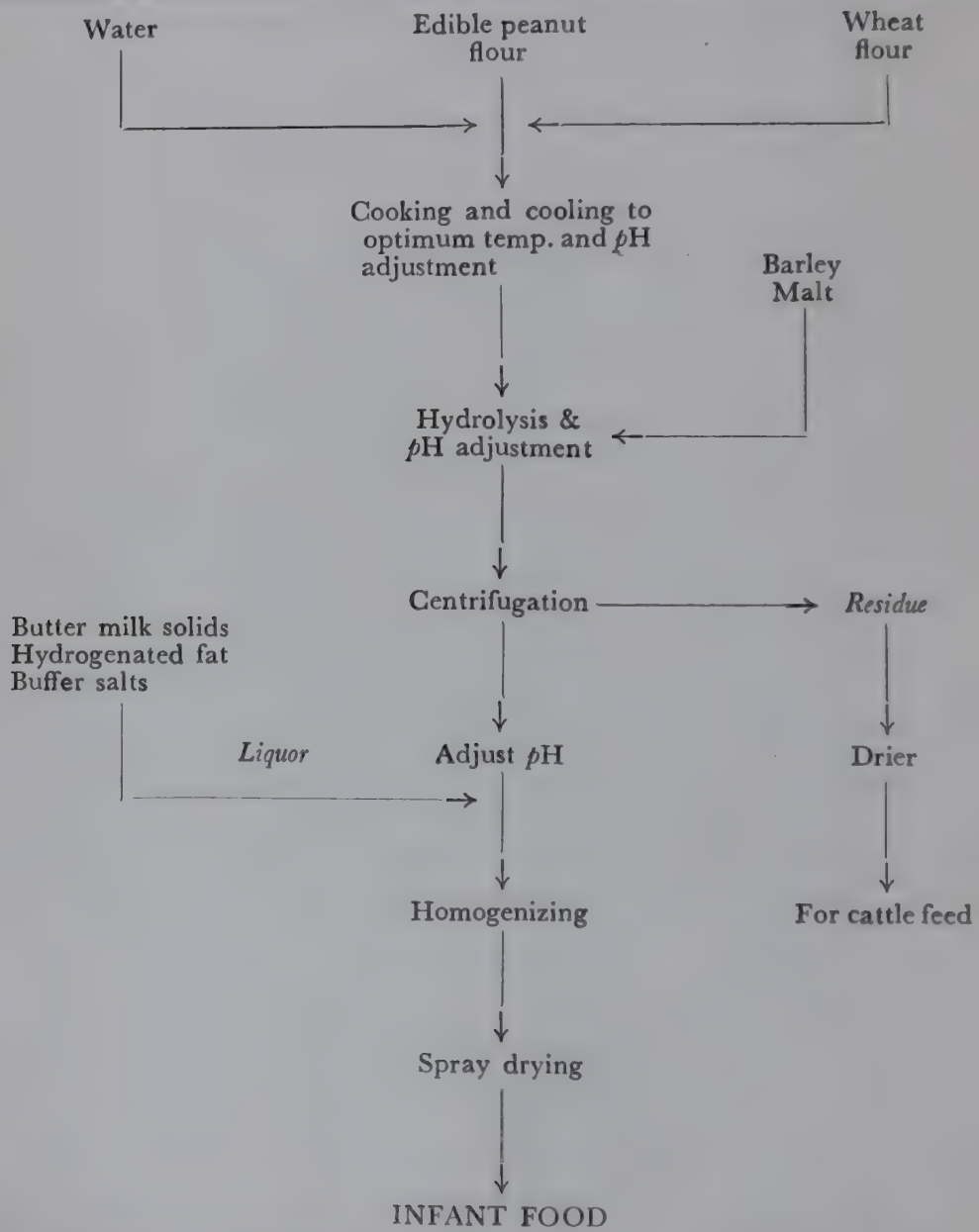
(Value per 100 g.)

Moisture	3.0 g.	Carbohydrate (by diff.)	49.0 g.
Minerals	5.0 g.	Calcium	1.0 g.
Protein*	25.0 g.	Phosphorus	1.0 g.
Fat	18.0 g.	Iron	6.0 g.

*The protein is made up of 13.5 parts of groundnut protein, 9.0 parts of milk protein and 2.5 parts of cereal of cereal protein, fortified with vitamins & minerals.

Table 3—Protein efficiency ratio of infant food based on peanut flour

Diets	Protein level (%)	P.E.R. (weeks)	Corrected P.E.R .
Infant food	10	3.0	2.5
Infant food + methionine	10	3.4	2.8
Infant food	15	2.6	2.2
Skim milk powder	10	3.6	3.0
Skim milk powder	15	2.9	2.4
Precooked weaning food			
Weaning food	10	2.2	1.8
Weaning food + methionine	10	3.0	2.6
Skim milk powder	10	3.6	3.0
Toned vegetable milk (Lac-Tone)			
Toned vegetable milk	10	2.8	2.3
Skim milk powder	10	3.7	3.0

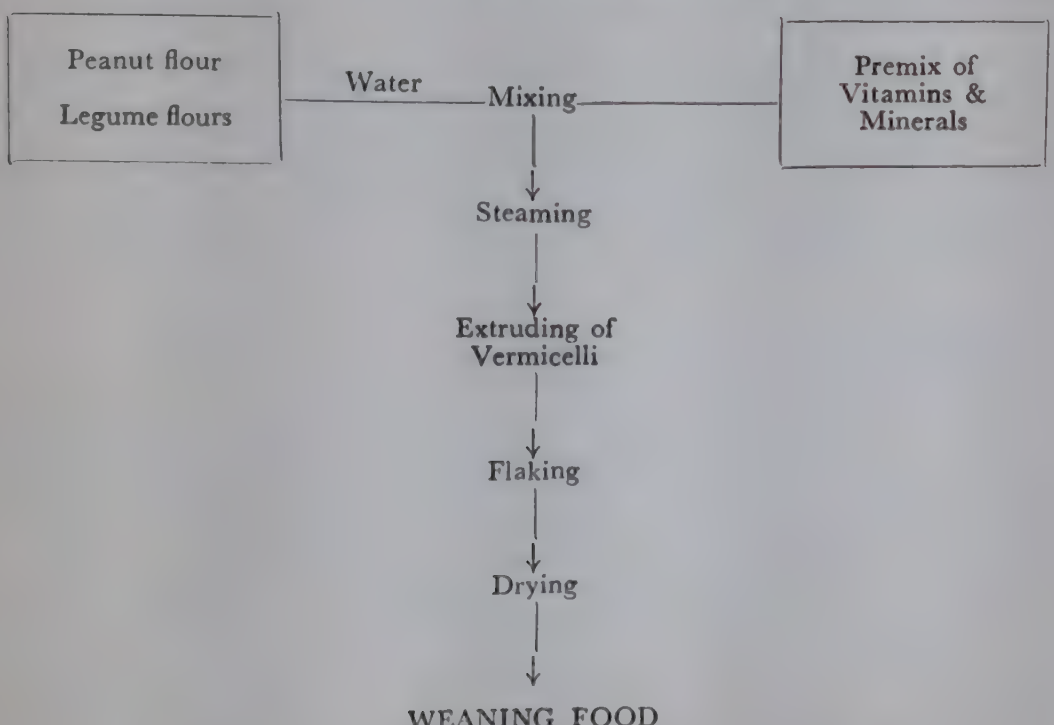


FLOWSHEET 1 — PRODUCTION OF INFANT FOOD BASED ON PEANUT FLOUR AND BUTTER MILK SOLIDS

It is heartening to note that one of the progressive infant food manufacturers of the country have agreed to cooperate fully in the production of this.

Vegetable proteins for extending the fluid milk resources

A second project in which active work is going on in our Institute is the preparation of substitutes for fluid milk. Many of the urban milk processing plants in the country are not able to make use of even quarter of their capacities for pasteurizing and bottling of liquid milk. To extend the availaible milk, 'toned milk' and 'double toned milk' are being prepared in many of the dairies. In Bombay alone 1.27 lakh litres of toned milk were being produced per day. But this programme of toning milk is dependent on the supply of skim milk powder from abroad, either as a free gift from International Agencies or by purchases. There is a general scarcity of skim milk powder all over the world as most of the welfare programme of the International Agencies are based on skim milk powder. As a consequence of this scarcity of skim milk powder, some dairies have even given up the production of double toned milk. It is in this field that vegetable protein could be used to supplement the milk resources. We have now been able to perfect a process of preparing toned vegetable milk (Lac-Tone) using groundnut protein isolate, liquid glucose and salts in place of skim milk solids and by blending these with buffalo milk and pasteurizing, obtain a toned vegetable milk having the composition, taste, colour and flavour of toned milk (Flowsheet 2). It is fortified with vitamins and could be used in a similar manner to toned milk either as such or for preparation of *dahi*, coffee, tea or even for milk sweets. Lac-Tone has also been very successfully used for preparation of sterilized flavoured milk. This has a longer shelf life and could be stored and sold like other flavoured milk. The Worli Dairy at Bombay has now carried out experiments with this and find it very suitable for preparation of sterilized flavoured milks. This could be introduced in school feeding programmes.



FLOWSHEET 2 — PREPARATION OF PRE-COOKED WEANING FOOD

Table 4—Cost calculation of preparation of Lac-Tone

(Unit of production 10,000 litres per day)

Material		Rate	Quantity	Cost (Rs)
Milk	Fat 7.5% SNF 9.0%	Re 0.80/lit.	5000 kg.	4,000.00
Wet protein	Moisture 50% Protein 45%	Re 2.00	390 kg.	780.00
Liquid Glucose	Moisture 15%	Rs 1400/1000 kg.	294 kg.	411·60
Sugar		Rs 1200/1000 kg.	76 kg.	91·20
Vitamins & salts		Rs 30/1000 kg. of final milk		300·00
			TOTAL	5,582,80
Deduct for fat removed 175 kg. or as butter 206 kg. at Rs 8.50/kg. and add cost of 175 kg. of milk at 2% fat (0.45 P./kg.)				1,672.25
Total cost of raw materials				3,907.55
Services and labour charges and overheads Rs 60/1000				600.00
Ex-factory cost of 10,000 litres of foritified toned milk (fat 2.0, SNF, 9.5 protein 3.5).				4,507.55
or cost per litre of toned milk ex-factory Re 0.45				

Lac-Tone has 50 per cent milk solids and could be used to double the available milk resources. Moreover since the fat content of this is only 3 per cent, it is possible to skim part of the buffalo milk and obtain butter and thus reduce the cost of production (Table 4).

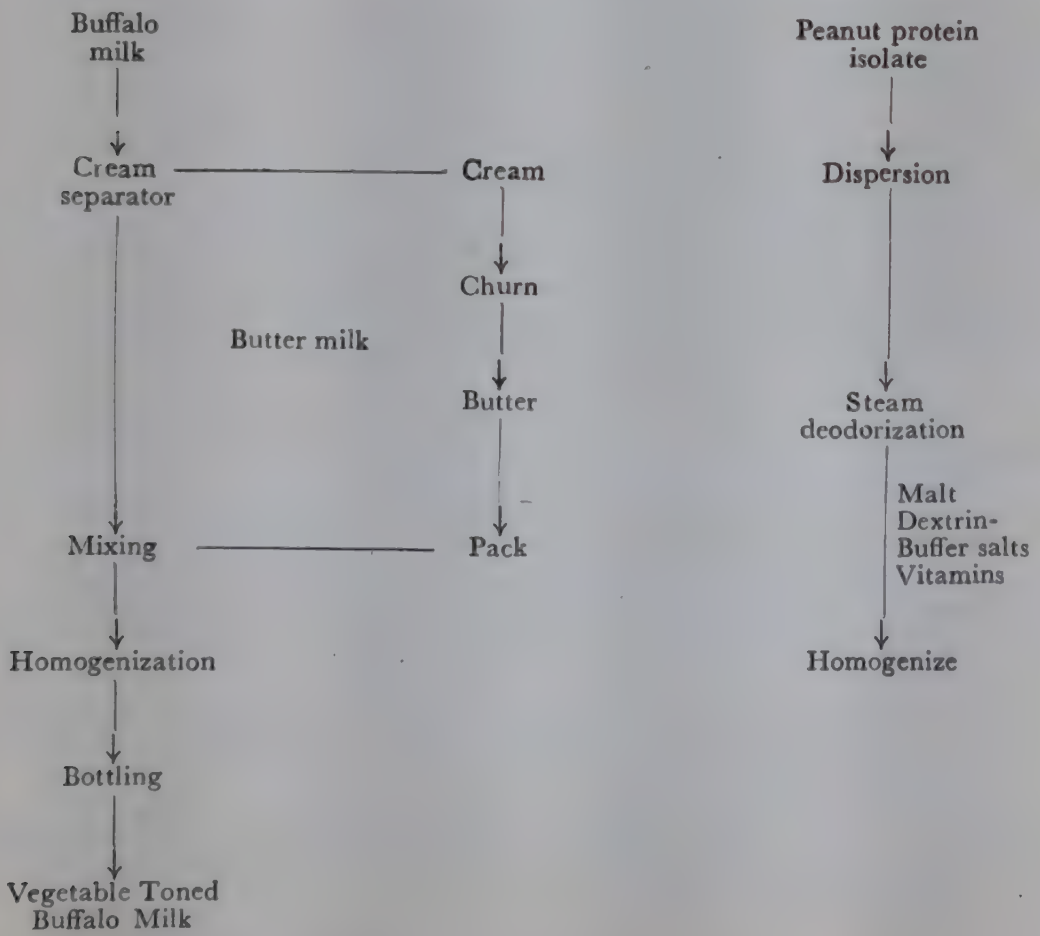
We have also carried out experiments on the preparation of spray dried vegetable milk powders which could be used in place of milk in coffee and tea. One product which contains about 30 per cent milk solids has been instantized so that it could be mixed easily with coffee or tea. This could release considerable quantities of milk which are now being used in coffee and tea houses and thus enhance the available milk for use of infants and children.

Vegetable proteins in weaned foods

Another field in which we have tried to supplement available milk resources is in the use of vegetable proteins in the production of foods for weaned children. The weaning stage of a child is a very critical age and negligence of the nutritional requirements of this group always results in handicapping it throughout life. In our country this group of children is always fed on foods similar to that taken by the adults, mainly cereals and cereal gruels, resulting in protein malnutrition. In an attempt to provide better food for this group the UNICEF has suggested the preparation of roller dried weaning food containing skim milk powder. This again is difficult to achieve as there is scarcity of milk powder. In our experiments we have prepared a roller dried weaning food based entirely on vegetable

protein (groundnut flour pulses and rice) (Flowsheet 3). We have found that it has a protein efficiency ratio equivalent to milk, when fortified with methionine (Table 3). It is precooked and hence could be fed to children as such without much preparation, and it has a flavour and taste which are relished by children.

We have at present an estimated availability of 3·3 million tons of groundnut kernel equivalent to 2.0 million ton cake. It has been estimated that during 1963–64, 800,000 tons of groundnut cake were exported and the remaining is utilized for feed and fertilizer purposes in the country. For the manufacture of another 5,000 tons of infant food we require only 3,000 tons of edible quality groundnut cake which can be easily made available. The CFTRI has already set up a 3 tons groundnut flour plant at Coimbatore and a few more units can be easily set up with locally fabricated equipment and machines. The 10 tons per day UNICEF aided plants are also available and these have to be commissioned. Similarly, to increase the present availability of milk of 22 million tons by 25 per cent, i.e. by another 5.5 million tons we require only 1 lakh tons of protein or about 2 lakh tons of meal. Thus if only 1/4 the quantity of cake that is being exported could be used for these two programmes, we will be producing enough vegetable protein-milk based foods equivalent to million tons per annum. Apart from groundnut we have potential of supplies of cottonseed cake, sesame, coconut etc. which could be used for such preparations. In addition, vegetable proteins can also be used in the development of a variety of other products like icecream mixes, biscuit and bakery products, meat-like product, etc.



FLOWSHEET 3 — PRODUCTION OF VEGETABLE TONED MILK (LAC-TONE)

Table 5—Composition of weaning food based on peanut flour and pulses

(values per 100 g.)

Moisture	2.7	Thiamine (mg.)	1.1
Protein (N×6.25) (g.)	35.0	Riboflavin (mg.)	1.8
		Vitamin A (I.U.)	3000
Fat (g.)	4.0	Vitamin D (I.U.)	300
Calcium (g.)	0.9	Vitamin C (mg.)	30

Fortification of these foods with methionine and in some cases both methionine and lysine may be necessary. But this will not enhance the cost very much as the quantities required are very small. In the case of spray dried infant food the additional expenditure involved is only of the order of 5 paise per kg.

In the preparation of these foods it has been attempted to blend the ingredients in such a way that the components supplement each other. For example groundnut protein is poor in lysine but in the roller dried weaning food this is blended with Bengalgram and green gram (*masur dal*) which are rich in lysine.

It has often said that utilization of oilseed cakes deprives the animals of their concentrates. Though the quantity required for human feeding may not be much, it is still a drain on the available resources for cattle and poultry feeds. But it is to be considered whether it is necessary that cattle and poultry should depend on oilseed cakes. Experiments carried in several laboratories in India have established that leafy vegetation could be used for livestock feeding. Preparation of protein concentrates from leaves has been evolved to a high level of efficiency. These protein concentrates containing 50 per cent or more of protein could advantageously be used for cattle feeding. The effective utilization of agricultural and farms wastes for livestock feeding would make available increasing quantities of oilseed meals, for the betterment of the nutrition of the human population.

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White Sugar Manufacture without Sulphur by Defeco-Melt-Crystallization Process

S. C. GUPTA
National Sugar Institute
Kanpur

Sulphur forms an important material for use in the manufacture of direct consumption and plantation white sugar. The quantity of sulphur consumed varies with the process of clarification, 0.6 to 0.8 per cent on sugar in the sulphitation and 0.2 to 0.3 per cent on sugar in the carbonation processes. India has to import sulphur for use in sugar industry and in other chemical industries. The annual requirement for the sugar industry is of the order of 20,000 tons involving a foreign exchange of Rs 50 lakhs.

There is a world shortage of sulphur today. In addition, India faces foreign exchange difficulties. The position of importing sulphur this season thus became acute. Government was in difficulty. Industry was faced with the problem as to how the use of sulphur for white sugar manufacture could be cut down or eliminated. The National Sugar Institute concerned itself with the task of finding out and suggesting an appropriate solution. Accordingly, in order to focus the attention on the subject, the Institute arranged a Seminar on September 10, 1965 under the auspices of the Sugar Technologists' Association of India. A record number of technologists and other representatives attended the Seminar and took part in discussions. Various suggestions for reducing the sulphur consumption by modification in equipments and process were suggested. It was generally agreed that sulphur consumption could be cut down to some extent by taking certain precautions.

Since the saleability of sugar is dependent on its quality, it was obvious that any attempt at reduction or elimination of sulphur consumption should not impair the quality of sugar as far as possible. It was naturally the responsibility of the National Sugar Institute to give serious consideration to this problem and to offer a practicable solution possibly before the commencement of 1965–66 crushing season. It occurred to me if crystallization of sugar could be carried out in a high purity medium, the resulting sugar should be of a better quality. Employing this principle, an experiment was carried out at the Hindustan Sugar Mills, Gola. Raw sugar was melted and fine grain sugar from hopper as seed was developed with this high purity melt. The sugar produced was of a superior quality conforming to ISS 30 grade colour. Encouraged from the results of the experiment, a process of manufacture of white sugar was worked out.

The new process called the Defeco-melt-crystallization process (DMC process) consists of manufacturing raw sugar by defecation process where only lime is used and no sulphur is required. The raw sugar produced is melted and this high purity melt is utilized for developing the nucleus grain taken from an intermediate project namely B sugar (preferably double-cured). This scheme is illustrated in Fig. 1.

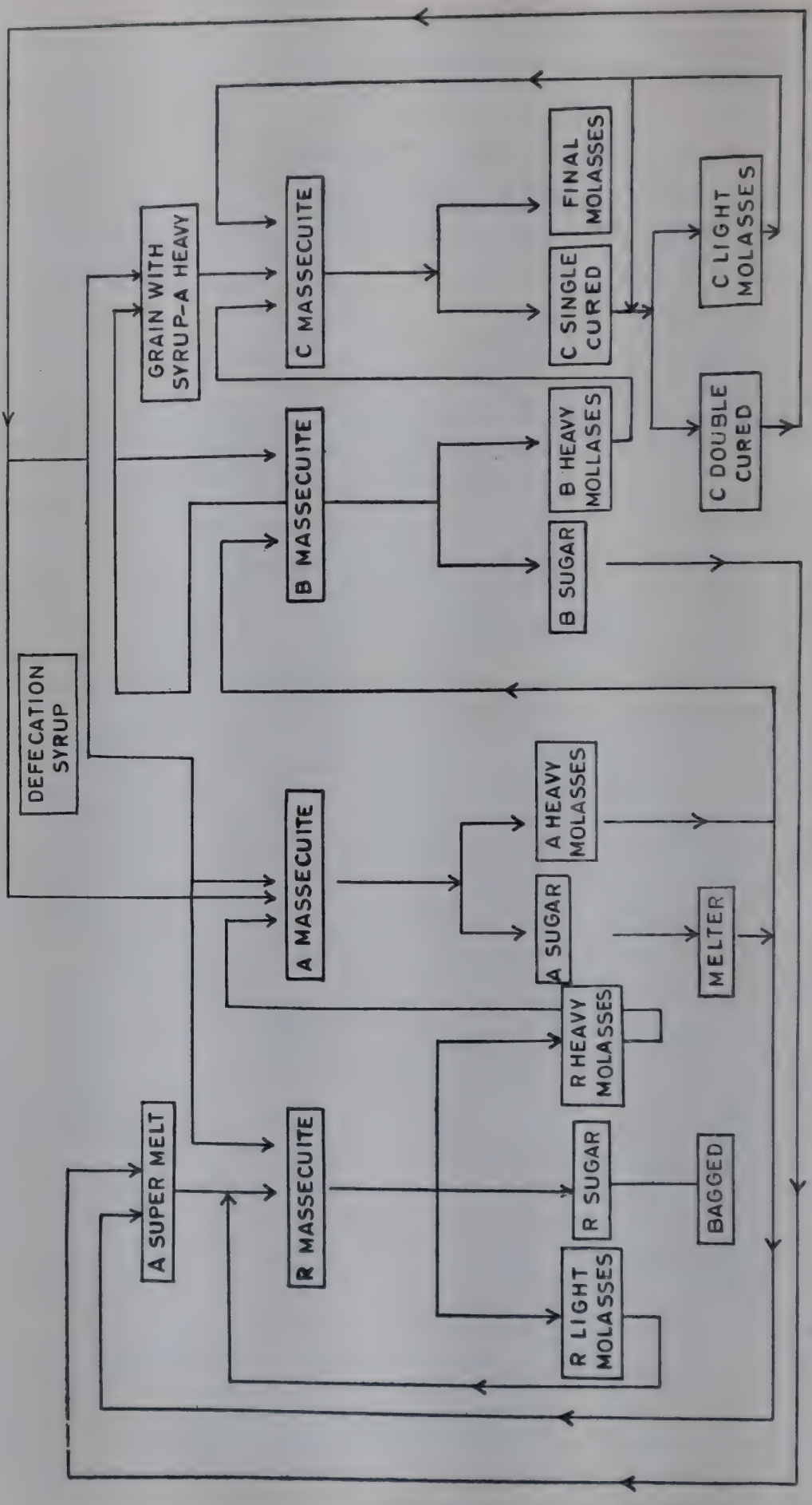

FIG. 1 — BOILING AND CURING SCHEME FOR THE DETECO-MELT-CRYSTALLIZATION PROCESS

Efforts were made to carry out the trial of the DMC process on a factory scale. Thanks to the cooperation and collaboration of the Pandavapura Sahkari Sakhar Karkhana, the trial was carried out in that factory from October 11, 1965 under the guidance and control of the officers and staff of the Institute deputed for this purpose. I am glad to state that the trial has been successful and a sugar of about 30 colour in ISS 'D' & 'E' grades was produced. Necessary technical data have been collected. Further, the process has worked satisfactorily for about a week. It is proposed to publish a technical paper on the subject very shortly.

Experiments have also been done for the production of white sugar by double-curing of raw sugar. This gave white sugar conforming to ISS grade D-29. Following the defecation of raw sugar manufacture, attempts were also made to melt the double-cured C sugar and use double-cured B sugar as seed for A massecuite which was double-cured. The sugar thus produced was much above ISS D-29 grade. Some other modifications like using double-cured C sugar as seed for B and double-cured B sugar as seed for A, and then double-curing the massecuite have also been done with success. Fine sugar from hopper as seed for A massecuite with the melting of double-cured B & C sugars have also given good results.

It is obvious, therefore, that good quality white sugar can be produced without any sulphur. Further a process (DMC process) has been established by the Institute and this can now be confidently adopted by the Industry. The process would have to be suitably modified according to the plant and equipment available in each factory. Necessary technical advice is available from the National Sugar Institute.

Some Suggestions on Import Substitution in the Dairy Industry

A. T. DUDANI, V. R. BHALERAO & M. R. SRINIVASAN
National Dairy Research Institute
Karnal (Punjab)

The modern dairy industry in respect of milk production and technology of milk processing remained totally neglected in this country until recently. In fact even the First Five Year Plan launched in 1951 had only a token outlay on dairy development. It was only in 1956 that in the Second Five Year Plan some serious consideration was paid to setting up of modern milk processing plants in cities with a popu'ation of over one lakh. This has been followed by setting up of a few large-sized milk products (western type) manufacturing units. Equipment for number of these plants in the public sector have been received as gifts and were imported from various overseas manufacturing agencies. This situation was inevitable considering that there were no indigenous manufacturers; absence of the necessary market, lack of an industrial base and technical know-how were some of the other contributory factors leading to such a situation.

Consequent upon the setting up of modern dairy plants and the resulting demand during past few years, a few manufacturing units have sprung up largely in collaboration with overseas firms. The dependence on imported items for manufacture of finished goods has been the main stumbling block in the way of rapid development of these firms. For example, we depend on import for such basic and simple requirements as milk cans. Equipment apart, chemicals like alginate (for ice-cream), rennet (for cheese) or amyl-alcohol (for fat test) are also to be imported. Same is the case with raw materials for packing, such as butter-paper, tin-plate, etc.

While it is undoubtedly true that no country can be completely independent it is equally true that no country can rely for its progress on imports for every conceivable need of its industries.

It, therefore, augurs well for the country that driven by the present difficult situation arising from foreign exchange shortage we are bending our energies to the task of import substitution. We, in the Dairy Industry as in other spheres must concentrate on the task of reducing considerably, if not eliminating completely, our reliance on import for dairy development.

An attempt has been made in the present communication to list some of the requirements of the dairy industry under different headings. The requirements have been grouped under 3 heads for convenience to facilitate understanding of the present position. The lists are by no means complete but include the major items which in the experience of the authors merit consideration. The authors will consider their objective achieved if they succeeded in focussing the attention of all concerned on the urgent need for

initiating steps to achieve self-reliance and self-help in the matter of production of dairy requisites. It is only such a realization leading to immediate action which will speed up the present targets for the growth of the industry and enable it to play its rightful role in the well-rounded development of the country.

A successful import substitution programme must take into consideration manufacture of goods of standard quality at prices which are at least comparable with the landed cost of imported items. In this connection one could profitably utilize the information already made available by the ISI who during the last few years have come forward with specifications for several items of interest in the dairy industry. Proper planning of production programmes based on such available information will help to reduce the avoidable multiplicity of various prices of equipment and also help in the production of interchangeable parts suitable for different purposes and easy hook up.

Annexures I to III refer to items regarding which sufficient information already exists and could be exploited for manufacture, items on which some information exists and could profitably be utilized for manufacture with some additional experimentation and items which need intensive work before they could usefully be employed in the industry respectively.

ANNEXURE I

Items which can be manufactured with the existing know-how in the country and for which established market exists

1. Plate pasteurizer
2. Continuous ghee making equipment
3. Continuous *dahi* making equipment
4. Insulated boxes for transport of ice-cream and butter
5. Animal rennet for cheese manufacture
6. Rennet substitutes of non-animal origin
7. Reagents for phosphatase test
8. Freeze dried starter cultures
9. Detergent and sanitizer compounds
10. Fat testing reagent (alkaline type)
11. Milk testing kit
12. Standard glassware for bacteriological and chemical analysis (e.g. Breed pipettes, butyrometers)
13. Sediment testing equipment for milk
14. Ghee testing equipment
15. Ice-cream over-run computer
16. Packaging material for dairy products
    - 16.1 Indigenous wackplate in place of imparted tin plate for packing ghee, condensed milk, processed cheese
    - 16.2 Indigenous paper board (treated) for packing ice-cream, cottage cheese
    - 16.3 Indigenous plastic bags for packing with powder, cottage cheese
    - 16.4 Indigenous grease-proof paper instead of parchment imparted paper for packing retail butter packets

ANNEXURE II

Items on which some information exists and could be manufactured with some additional experimentation

1. Butter moulding machines
2. Milk condensing and evaporating equipment
3. Condensed and evaporated milk filling and closing machines
4. Roller and spray drying machines

5. Gas packing equipment for milk powders
6. Packaged—Ice-cream making units
7. Continuous *khoa* making equipment
8. Annatto cheese color
9. Comparators for phosphatase, resazurin and water analysis
10. Methylene vlue and resazurin tablets
11. Density hydrometers for milk testing
12. Rubber and other rubber like materials used for SEALS & GASKETS in dairy equipments

12.1 *Weigh bowl*

'O' Rubber Ring Seal

12.2 *Positive pump*

'O' Rubber ring seal
Rubber oil seal-shaft-front
Rubber covered rotars five lobe
Ring seal rubber
Seal rear oil (rubber) of the shaft
'O' ring rubber

12.3 *Can washer*

Hydraulic pressure hoses (Rubber)
Hydraulic cylinder oil seal (Rubber)
Rubber cushion
Rubber sheet gasket for air inlet window
Motor oil seal
Water pump oil seal
Shock obsorber seals (rubber)

12.4 *Pipe line fittings*

'O' ring gasket
Flat ring gasket
C.I.P. clamp gasket

12.5 *Tri-process clarifier*

Bowl ring (rubber)
Cream seal
Gasket
Coupling ring
Milk outlet seal
Top bearing cushion (rubber)
Bearing gasket
Rubber ring
Rubber valve
Top bearing rubber mount
Top bearing rubber

12.6 *Balance tank*

'O' ring rubber
Pipe rubber seal

12.7 *Centrifugal milk pump*

Slip ring rubber
Shaft seal miner
Shaft seal with rubber ring

12.8 *HTST Pasteurizers*

Crane seal-pump
Plate rubber left
Plate rubber right
'O' ring
Flat ring
Semi 'O' ring
Rubber plugs
Outer filter cover 'O' ring
Filter valve 'O' ring
Temperature outer cover gasket rubber

12.9 *Bottle filler & Capping machine*

Filling valve rubber
Spacing collar (synthetic rubber)
Gland rubber
Ejector rubber
Air pump washer
Sealing bend
Rubber seal (capper)
Valve rubber
Thrust ring (synthetic)

12.10 *Bottle washer*

Discharge bottle guides
Rubber buffer for load table
Buffer wheels
Rinse pump suction hose
Rubber sealing washer
Rubber washers
Belts 'V'

12.11 *Cheese vats*

Packings

12.12 *Butter churn*

Gasket of churn gate
Gasket of inspection glass window
'V' belts
Seal for the motor

12.13 *Butter moulding machine*

Rubber gasket
Belt 'V'

12.14 *Homogenizer*

Packing seat
Packing washer
Homogenizer seat
Valve seat packing
'V' belt
Gauge block gaskets

12.15 *Ice-cream freezer* (Batch type)

Gasket back plate
Gasket back bearing
Gasket gear box
Gasket chain case
Gasket pinion plate
Gasket for compressor

12.16 *Condensed milk plant*

Lid gaskets
Rubber coil joints
Rubber gaskets
Gasket of inspection window

12.17 *Ice-cream hardening cabinet*

Gasket for lid & gasket for base of the lid

12.18 *Butter oil plant*

Gasket for lid
Gasket for inspection window
Gasket for pipe fittings
Gasket for lid of receiving vat

12.19 *Milk storage tanks*

Gasket for doors
Gasket for glass inspection window
Belts for motor (agitation)

12.20 *Processed cheese unit*

Washers for cylinders

12.21 *Ammonia compressor*

Gland seal
Oil seal
Gaskets

12.22 *Cold store doors*

Gasket for the doors
Gasket for the window

12.23 *Spray drier*

Gasket for inspection window
Seals for blower lids

12.24 *Cream separator* (hand)

Rubber ring of the bowl

12.25 *Batch pasteurizer*

Gasket for the outlet valve

12.26 *Ageing vat* (cream)

Gasket for the outlet valve
Belt for the attached compressor

12.27 *Power cream separator*

Rubber ring of the bowl
Belt connected with the motor

12.28 *Miscellaneous*

(a) Rubber mats for cleaning stainless steel parts
(b) Steam hose
(c) Water hose

ANNEXURE III

Items which need intensive work before they could usefully be employed in the industry

1. Milking machines
2. Automatic bottle fillers
3. Automatic bottle washers
4. Aluminium alloy butter churns
5. Butter packaging machines
6. Freeze drying equipment
7. List of dairy equipment where aluminium can replace stainless steel:
   - 7.1 Weigh bowl
   - 7.2 Strainer attached to the weigh bowl
   - 7.3 Dump tank and its lid
   - 7.4 Upper housing of clarifiers
   - 7.5 Housing of motor attached to the clarifier
   - 7.6 Balance tank
   - 7.7 Float of the balance tank
   - 7.8 Housing of the milk pump and motor
   - 7.9 Housing of the check thermometer (HTST)
   - 7.10 Gravity tank in between HTST and filler
   - 7.11 Milk bowl of the bottle filler
   - 7.12 Filler valve of the bottle filler
   - 7.13 Vent tube of the bottle filler
   - 7.14 Air pipe line from vacuum producer of the bottle filler
   - 7.15 Float of the bottle filler
   - 7.16 Body (main) of the bottle filler

7.17 Housing of the capping press attached to the bottle filler

7.18 Foil conveyor attached to the bottle filler

7.19 Railings of bottle conveyor

7.20 Milk storage tanks

7.21 Window covers or lids of can washer

7.22 Window covers or lids of bottle washer

7.23 Milk plunger

7.24 Milk stirrer

7.25 Milk sampler

7.26 Cream dipper

7.27 Aluminium milk cans

7.28 Butter churn

7.29 Cream strainer

7.30 Multipurpose tank

7.31 Feeding cup of homogenizer

7.32 Strainer attached to the feeding cup of the homogenizer

7.33 Body of the hardening cabinets of batch ice-cream freezer

7.34 Cover of the ice-cream compressor unit

7.35 Hopper of butter moulding machine

7.36 Frontal lid of butter moulding machine

7.37 Housing of powder conveyor attached to roller drier

7.39 Cheese vats and their lids

7.40 Cheese trier

7.41 Whey strainer

7.42 Cheese and whey agitator

7.43 Measuring plates for milk in cheese vats

7.44 Measuring plates for milk in milk vats, etc.

7.45 Holding clamps of Homogenizer head

7.46 Milk holding tank and lid of bulk coolers

Pesticide Situation in India—Present Situation and Future Trends

H. A. B. PARPIA & S. K. MAJUMDER
Central Food Technological Research Institute
Mysore

During the last two decades there has been a shift on the use of pesticides from inorganic and plant preparations to the synthetic organic pesticides. The prodigious growth of the pesticide industry in recent years, largely based on the production of chlorinated hydrocarbons, phosphatic organic esters and carbamates, has been due to the spectacular effects on the pests of plants, animal and man's possessions.

A recent report of the State of California from the United States shows that the cost of control of losses attributable to insects and mites to be near the 0.5 billion dollar mark. The total expenditure for preventing losses from insect pests in the country like USA goes over 15 billion dollars per annum. In India the total losses have been estimated to the tune of Rs 45,000 million, out of which more than 70 per cent are contributed by insects moulds and rodents. Studies have revealed that in India alone the use of pesticides have reduced pestilences such as malaria, yellow fever and filariasis from 78 to 5 million cases per annum. The threat of pests to our economy could be comprehended on the basis of our knowledge that a single flight of locusts can weigh 50,000 tons consuming its own weight in food daily which is nearly the food of 5 million humans.

The need for higher food output with the increase in population has become imperative. 'Food explosion' to match the 'population explosion' can be only substantiated with the technological advances in food production, conservation and utilization. The pest control effort inherent in the struggle for existence and survival of the fittest has played a vital role in keeping up the food output throughout the world.

More than 120 different compounds are now available for the control of insects and mites. Out of these about 20 chemicals are produced in vast quantities and applied throughout the w rld. The pesticide industry has, therefore, come to stay as the means for the survival of human population and to fight against the pests, diseases and other pestilences. In India the trend of increase in the use of pesticides can be noted from Table 1.

The spectacular lethal activities of substances to insect pests and disease vectors have encouraged their use throughout the world. Unfortunately these have been applied without much respect with regard to the implications of extensive use and misuse on the environmental pollution. The aspects of the chronic and acute toxicities to human beings and wild life have been considered by several learned bodies the reports of which have given rise to serious controversies. Out of the range of pesticides which are being

Table 1—Sale of pesticides for plant protection in India during 1956–62

Pesticides	Formulated quantities (in tonnes)						
	1956	1957	1958	1959	1960	1961	1962
Aldrin	278	158	332	259	864	1,068	767
BHC	4,129	8,665	15,147	18,868	22,597	20,622	24,318
Chlordane	39	55	53	16	13	21	19
DDT	262	425	1,516	1,544	1,086	787	6,363
Dieldrin	138	64	52	79	95	45	119
Endrin	63	58	101	152	241	218	495
Heptachlor	—	—	4	7	2	52	41
Lindane	260	193	8	26	60	51	154
Taxaphene	5	—	2	3	1	1	65
Malathion	—	11	11	43	155	81	41
Ekatin	—	—	—	4	7	8	5
Parathion	35	23	80	94	337	143	563
Diazinon	—	6	8	30	25	18	28
Chlorobenzilate	—	—	14	16	40	57	47
Aramite	6	1	—	—	—	—	—
Lime sulphur	175	78	60	n.a.	n.a.	—	—
Calcium arsenate	—	—	6	13	12	28	10
Nicotine sulphate	2	2	2	4	26	3	3
Pyrethrum products	2	4	19	5	27	17	24
EDCT mixture	537	502	338	1,174	1,134	321	246
Ethylene dibromide	—	1	13	1	2	13	25
DD & nemagon	—	1	1	1	4	1	2
Methyl bromide	—	2	2	2	4	6	12
Cyanides	—	3	1	61	60	—	—
Zinc phosphide	5	10	40	92	178	243	128
Misc. pesticides	30	41	15	153	511	268	1,019
Copper sulphate	757	1,664	969	1,673	4,037	4,544	5,925
Copper oxychloride and Cuprous oxide	2,495	3,606	2,503	3,299	4,654	2,803	3,383
Sulphur dust	105	141	267	982	208	357	607
Wettable sulphur	24	31	32	71	115	—	—
Mercurial compounds	42	88	87	186	298	302	477
Zineb	2	5	3	2	10	4	62
Weedicides	24	28	31	50	68	77	67
Spray oils	—	—	—	—	—	—	1,097
Solbar	—	—	—	—	—	—	3
Captan	—	—	—	—	—	—	8
Misc. combinations of pesticides	30	54	58	123	173	5,621	328

consumed in India, DDT, BHC, malathion, pyrethrum, copper oxychloride, ethylene dibromide, and carbon tetrachloride are being manufactured in the country. Other chemicals such as lindane, aldrin, dieldrin, endrin toxaphene, chlordane, parathion, diazinon, organic fungicides, organic mercurial and nicotine compounds, etc. are being imported to India for use in agriculture and food conservation. Rodenticides such as Warfarin, 1080, zinc phosphide are also imported in considerable quantities for control of rats and related pests.

These pesticidal chemicals are residual in nature and contaminate food, water and environment. Some are highly persistent and few are volatile and dissipate within a short time. Though the use of organic pesticidal substances is quite extensive, yet several inorganic substances based on lead, mercury, copper, arsenic, fluorine, sulphur, etc. are in vogue since quite a long time. The consumption of these inorganic pesticides, however, have been reduced considerably due to the availability of chlorinated, phosphatic and carbamate compounds and organic fungicides at low costs.

In India the pesticide industry is in its infancy. The installed capacities and actual production of the pesticidal chemicals are given in Table 2.

In view of the great need for augmenting the pesticide production in the country, it is desirable to take note of the reports of the learned bodies like the Weisner Committee to the President of United States and Cooke's Committee to Her Majesty's Government of United Kingdom and plan the pesticide production in the country, so as to prevent the chronic and acute toxicities to man and his animals and pollution of the environment with the undesirable pesticides. The trend of research in India and elsewhere have pointed out to the possibilities of using safer chemicals in the fields of agriculture, food storage and health. Anti-feeding agents, chemosterilants and repellents are being developed to the commercial level and specific toxicities of many substances to insects have been established in recent years. Activated kaolin, calcium phosphate and bacterial insecticides are found most

Table 2—Consumption of pesticides in India

(in tonnes)

Pesticide	Installed capacity	Production actual	
	1963	1963	1964
BHC	7,200	5,739	6,156
DDT	2,640	2,559	2,660
Malathion	190	84	97
Pyrethrin extract	—	427	42
Ethylene dichloride	300	—	46
Ethylene dibromide	100	100	—
Copper oxychloride	2,284	1,083	1,520
Organomercurials	91	46	50
Zinc phosphide	500	49	234
Barium carbonate	400	—	—

useful in food storage and control of insect infestation on food crops. Treatment of the houses, warehouses, factories, hotels, hospitals, dockyards and rural storages will, however, need in addition to these, other chemicals like malathion, lindane, DDT and pyrethrum in huge quantities. The substances will have to replace many of the highly toxic pesticides like endrin, dieldrin, aldrin and others which have low LD_{50} value for mammals and also are highly persistent in nature. The need for the pesticides in the field of food storage is given in Table 3 and the estimated requirements of pesticides in plant protection and malaria control during the Fourth Plan are presented in Table 4.

Table 3—Estimates for pesticide requirement during Fourth Plan for storage of foodgrains

Insecticides	Quantity (tonnes)	Cost (lakhs Rs)	Foreign exchange required (lakhs Rs)
Malathion (Tech,)	45	5.0	nil
Lindane (Tech.)	55	10.0	nil
DDT (Tech.)	35	1.5	nil
Pyrethrum (dust)	17	3.5	nil
Ethylene dichloride	300	3.0	6.0
Carbon tetrachloride	300	3.0	
Methyl bromide	250	30.0	30.0
Ethylene dibromide	500	15.0	nil
Phostoxin (Phosphine)	5	2.0	2.0
Other fumigants	10	0.6	0.6
Diluents and carriers (including formulation cost)	900	18.0	nil
Barium carbonate	85	1.7	nil
Zinc phosphide	20	0.2	nil
Warfarin (Bait)	5	0.2	nil
Other rodenticides	1	0.1	0.1
Insecticidal clay	5000	12.5	nil
Calcium phosphate	500	25.0	nil
Bacterial insecticide (*B. thuringiensis*)	2.5	1.5	nil
TOTAL	8030.5	132.8	38.9

Table 4—Estimated quantities of some pesticides proposed for the Fourth Plan

(Technical grade, tons)

Pesticide	Plant protection					Malaria control
	1966–67	1967–68	1968–69	1969–70	1970–71	1966–71
BHC	8160	16320	27200	27200	27200	3750
DDT	720	1440	2400	2400	2400	19235
Lindane	480	960	1600	1600	1600	100
Malathion	1080	2160	3600	3600	3600	—

Reviewing the progress made in the field of pesticides it appears to be logical to assume that the Indian industry will have to gear itself to the need for the production of insecticides of low mammalian toxicity and high toxicity to pests. The environmental pollution is to be reduced to the minimum and indigenous resources are to be exploited to the maximum. With the above aspects in view, augmentation of production of the following substances seem to be most reasonable in the next few years:

1. Malathion
2. Lindane
3. DDT
4. BHC
5. Pyrethrum
6. Ethylene dibromide
7. Ethylene dichloride
8. Carbon tetrachloride
9. Methyl bromide
10. Ammonia
11. Hydrogen cyanide
12. Phosphine
13. Bacterial insecticide (thuringiensis)
14. Insecticidal clay
15. Calcium phosphate
16. Zinc phosphide
17. Barium carbonate
18. Warfarin
19. Ethylene oxide and other newer promising substances

At the present moment, excepting malathion, none of the insecticides and fumigants suitable for application in the food godowns and processing factories are being manufactured in adequate quantities in the country. Licence for the production of lindane has already been issued to a few firms in India. Production, however, is yet to be started. There are possibilities for producing ethylene dichloride, carbon tetrachloride, methyl bromide and ethylene dibromide in the country but there is no possibility of producing phostoxin (phosphine) tablet in the near future. The know-how for it should be developed in the country. Indigenous production of all the fumigants and pesticides will have to be urged and import of the chemicals should be reduced immediately. Inefficient fumigants such as ethylene dichloride and carbon tetrachloride should be imported to the minimum and should be replaced by more efficient fumigants which will be economical for food disinfestation, and reduce the foreign exchange requirement to the minimum. Since bromine is produced in the country in sufficient quantities, encouragement should be given for the production of bromine based fumigants in India which will not only be cheapest but most efficient. Rodenticides such as barium carbonate, zinc phosphide and coumorin based compounds (anti-coagulants) should be encouraged in the country to save foreign exchange and also develop the indigenous industry.

Know-how for the production of (i) insecticidal clay, bacterial insecticide and calcium phosphate formulation and lindane are available with the CFTRI, Mysore, (ii) coumorin compounds with the NCL, Poona, (iii) ethylene dichloride and carbon tetrachloride at the Sree Ram Institute, Delhi and NCL, Poona, (iv) ethylene dibromide with the CSMCRI, Bhavnagar and Tata Chemicals Ltd, Mithapur, (v) pyrethrum based insecticides are available with the RRL, Jammu, (vi) methyl bromide with the Excell Industries, and (vii) ethylene oxide with the NCL, Poona.

Urgent action is to be taken for expediting the utilization of the processes and production of these insecticidal chemicals in the country as soon as possible.

In order to make it economical and efficient the 'servicing firms' with specialization should be encouraged in the country for taking up contract servicing according to prescribed methods and processes. Integrated development of industry for production of (i) basic chemicals, (ii) formulations, (iii) equipment for pest control, (iv) spare parts, (v) servicing and repair, and (vi) contract disinfestation should also be carried out.

Urgent Requirements for the Development of Fruit and Vegetable Processing Industries

G. S. SIDDAPPA
Central Food Technological Research Institute
Mysore

The fruit and vegetable preservation industry, which began in a small way some 30 years ago, has now been rapidly advancing. At the present time, this industry is mostly a small scale one, although there are a few comparatively larger units. These also are, however small when compared with similar establishments in the more advanced countries in the world and other industries in India such as Chemicals, Textiles, etc. A fairly large proportion of the preserved fruit and vegetable products manufactured in the country are traditional products such as *murabbas*, pickles and chutneys, recipes and processes for which have been handed down from generation to generation although further improved during the recent years by use of scientific knowledge. Application of modern practices of preservation such as canning, dehydration, refrigeration, etc. is fairly recent in this country. In the early stages, simple products such as fruit squashes, cordials, jams and jellies, etc. were being manufactured and sold within the country. Recently, however, a variety of other types of products, based on the application of modern technology, have been increasingly produced and sold within the country as well as outside. Some of the typical products such as canned mangoes, orange segments and pineapple, guava jelley, mango nectar and several other similar products are being eagerly sought for by buyers in different parts of the world. The quality of these products over the past decade has improved considerably as a result of sustained efforts by Government, private agencies and research institutions. The Fruit Products Order of the Government, which aims at controlling the quality of the products manufactured within the country to safeguard the interest of the consumer, has proved highly beneficial, in that it has enabled the manufacturer to gradually build up high standards for his products, with the result that these products are meeting with increasing demand and competing with similar products produced in different parts of the world. This is a very encouraging sign and the indications are that with continued efforts of quality control at every stage of manufacture of the different types of products there is every likelihood of increasing and wider demands for a variety of Indian fruit and vegetable products some of which are unique. Further, there is scope for meeting to an increasing extent the strategic demand of the defence services of the country for preserved fruit and vegetable products. Under these circumstances the defence services would be in a position to accept readily the products without having recourse to a series of checks and counter-checks as at present.

During 1958 to 1962 the production increased from 27,000 tons to 57,000 tons that is nearly twice which indicates vigorous growth of the

industry in spite of various handicaps. It is anticipated that by the end of the Fourth Plan it should be possible to increase the production of preserved fruits and vegetables to 150,000 tons or more and 20 to 25 per cent of this could be exported to other countries to earn foreign exchange.

Trained personnel

To achieve this desirable objective certain pre-requisites are essential. The first and foremost requirement of the fruit and vegetable preservation industry is the availability of suitably trained personnel. This in a large measure is being met by the efforts of the CFTRI and other agencies which over the past fifteen years or so have been training persons for the fruit and vegetable preservation industry in particular and food industry in general. A large number of these trainees are found practically all over the country occupying various positions—government as well as private —dealing with fruit and vegetable preservation and allied industries. With the introduction recently of the advanced course in food technology training leading to the M.Sc. degree in food technology of the University of Mysore after a two year post-graduate course it is hoped that a surer foundation has been laid for training scientists and technologists to meet the growing needs of the rapidly advancing food preservation industry in this country as well as in some of the countries of South Asia and the far East. The excellent research and training facilities available at the CFTRI enabled the FAO to establish the International Food Technology Training Centre (IFTTC) there so that participants from various countries in South Asia and the far East could be trained in Food Technology to suit their varying needs. In addition to the M.Sc. course and other short-term courses, facilities exist for advanced courses also, leading to higher degrees. Participants from other countries in this region will be admitted to these courses also.

In addition to the post-graduate courses, proposals exist to train persons actually engaged in the fruit and vegetable preservation industry at various levels, managerial as well as technical, by conducting short-term courses. The type of training envisaged is such that it will meet the requirements of the industry as a whole in every respect. For building up wider markets for preserved fruit and vegetable products, it is necessary to safeguard and ensure high standards in the finished products. To do this, it is necessary to employ proper quality control measures at every stage of production, right from the producing to the distribution stage. At present, the fruit preservation units in the country being small, it would not be easy for every unit to employ suitably qualified technologists to undertake quality control through laboratory analytical work, except perhaps in some of the larger units. It is, therefore, felt that a cooperative organization would be required to meet the needs for quality control in several of these units, wherever possible. The Fruit Products Order stipulates that every unit should have a qualified scientist on its staff. Production being small in several of these units, it would be rather difficult to enforce this measure, unless, in the interest of the industry as a whole and the larger interest of the economy of the country, the Government steps in to subsidise, at least to some extent, the expenses incurred by the units in maintaining a quality control staff at their premises. This might rather appear costly to begin with, but in the long run, it will be highly beneficial to the industry and the country, since the improved quality of the products as a result of quality control would bring in bigger dividends and wider markets.

Raw materials

In any industry, the quality of the finished products depends to a large extent on the quality of the raw materials, and this is particularly so in the case of preserved fruit and vegetable products. It is no longer true to say that the quality of the raw material is not of any great importance and that any fruit or vegetable, irrespective of its quality, would be suitable for preservation. The preserved fruit and vegetable products should be of the highest quality if they are to meet and satisfy the demands of the consumers who are rather sophisticated in their acceptance of food products. At present, in India, the right type of fruit or vegetable is not always easily available in large quantities for the preservation industry. The first and foremost step in this direction, should, therefore, be a realistic and integrated approach to the development of suitable varieties of fruits and vegetables in fairly large quantities in regions where they can be grown best. This is a long range problem which requires co-operative effort. It is necessary to focus on this attention of all the different agencies concerned —government as well as private. Fruit and vegetable products manufacture industry also can play an important role in this by initiating measures that would ultimately lead to a sound development of the industry. Dependence on fruits and vegetables available in the open market will not be satisfactory, especially when the object is to manufacture products of high quality which can be placed, without any hesitation or reservation whatsoever, in International markets where they are in demand. Once confidence in the quality of these products has been created, by making known to the buyers that every effort has been made within the country of production to utilize raw materials of high standards and to regulate the processing conditions, so that they satisfy all the hygienic standards for food production and that additives and other materials employed are strictly governed by legislative and regulatory measures, the industry would automatically have accelerated growth. In fact, the enforcement of the FPO, and recently the Prevention of Food Adulteration Act, has in a large measure been responsible for creating confidence and faith in several of the preserved fruit and vegetable products manufactured in the country and sent abroad. Through the existence of these governmental regulatory measures, importing countries are assured of the quality of the products. In view of this, it is essential that the fruit and vegetable products manufacturing industry in this country should adhere strictly to the regulatory standards and ensure that the products satisfy all the regulations and specifications laid down. This will be in its own interest, as well as in the broader interest of the country, and it will be possible thereby to build up a reputation abroad for Indian preserved fruit and vegetable products.

Fruits and vegetables being highly perishable, it is necessary to transport them quickly and carefully to manufacturing centres. Since they have to be often transported over considerable distances, it is necessary to provide for their safe transit by having the right type of railway wagons, road transport vehicles, etc. so that the materials do not suffer much damage during transit. Further, it will also be essential for the industry to install pre-cooling, as well as cold storage plants to extend the manufacturing season. A great deal of headway and spade work have to be done in this respect. There are, however, indications that the importance of this has been realized, with the result that some of the larger concerns have installed small refrigeration units for temporary storage of fresh fruits and vegetables before they are actually processed into products.

Other important raw materials

Cans, bottles and other flexible packaging materials are used on a wide scale in the packing and distribution of preserved fruits and vegetable products. At present the Indian fruit preservation industry has to depend largely on imported tin plate of suitable quality. For the canning of fruits and vegetables, it is necessary to employ the right type of tin plate—plain or lacquered. In the interest of the canning industry, which is a strategic one, it is absolutely essential for India to produce its own tin plate, be it hot-dipped or electrolytic. It is understood that the Rourkela Steel Plant is likely to go in shortly for production of these tin plates for use in the food canning industry. The work at the CFTRI on a comparative evaluation of different types of tin plates for their suitability for canning fruits and vegetables and other food materials has indicated the pos ibi ity of d velop- ing indigenously the right type of tin plate. Attempts to produce other important components of the open top sanitary cans, namely, lacquer, sealing compound, etc. have been fairly successful as revealed by laboratory investigations, and there is, therefore, every possibility for developing these important materials so that in the long run, the country could produce its own cans for canning foodstuffs. As regards glass containers, improvement required by the fruit preservation industry, there is already noticeable improvement. It is, therefore, to be expected that in the near future, it would be possible to develop still better bottles, closures, etc. in the country. Flexible packaging materials are required for packing some of the products such as dehydrated fruits and vegetables fruit powders, etc. India is still to produce the right type of such packing material. It is, therefore, necessary to take urgent action in the matter so that an indigenous flexible packaging material industry could be built up quickly to meet the increasing demands for such materials.

Pectin

At the present juncture, India has to depend entirely on foreign sources for its supply of pectin which is required for the manufacture of jams, jellies, etc. There is considerable restriction in getting this from abroad. Fortunately, however, over the past few years, systematic investigations conducted at the CFTRI have shown that it is possible to produce pectin of high quality from indigenous materials such as green papaya, citrus wastes, etc. In the case of the papaya, the great advantage is that the process of production of papain, which is the primary product, and of pectin which is a secondary product, can be integrated so that the whole process becomes highly economical. Actually, a small-scale pilot plant has been set up at the Institute for the production of 10 kg. of pectin per day from raw papaya obtained after the extraction of the latex for the production of papain, which is the primary product. This has proved highly useful in gauging the feasibility of indigenous production of pectin. Actually, pectin produced at the Institute has been found to be of high gel grade and readily acceptable to the user industry. This pilot plant has been designed and installed locally, and preliminary runs have shown that pectin of high quality could be produced. Some of the pectin produced has already been released to the industry. It is possible to scale up the process as well as the plant, so that practically the entire needs of the fruit and vegetable industry for pectin could be met indigenously. Citrus peels and pomace, readily available as waste products in the larger citrus processing units in the country, as well as apple pomace from the apple juice and cider factories would serve as useful raw materials for the production of pectin.

Preliminary work has already shown that citrus wastes could be readily employed for the purpose. It should be possible for a government or private agency to take up large-scale manufacture of pectin from indigenous raw materials although the demand for pectin in the near future is rather small (50–60 tonnes per annum). It is however, a highly essential material required in the fruit preservation industry and it is, therefore, essential to set up this industry as early as possible.

Other additives and preservatives

Other raw materials such as citric acid, potassium metabisulphite, permitted food colours, essences, etc. which are required by the fruit and vegetable preservation industry, are partly imported and partly manufactured within the country. It would, therefore, be desirable to set up units for their production so that the entire demand for them could be met by indigenous production.

Equipment, design and fabrication of small units

At present, the fruit and vegetable preservation units in the country are small in comparison with similar units in some of the other countries. Most of the equipment employed is manually operated. This often leads to high cost of production. It is, therefore, necessary to employ or install, to a limited extent at least, more efficient units for the different processes. One cannot, however, fully justify the installation of completely automatic lines. For instance, although it is desirable to employ a Ginaca machine in a pineapple canning factory, the supply of fruit available for canning is so small that it would not be possible to feed even one machine, and furthermore than one machine will be required to deal with different sizes of fruit. Such high speed automatic machines can only come into use when the raw material is available in very large quantities as in USA, Australia, etc. Till then, it will be necessary to design suitable small scale units which would work efficiently and do the same thing as a Ginaca machine. This applies to several other units of equipment such as washers, graders, blanchers, etc. employed in the fruit and vegetable preservation industry. There is thus urgent necessity for designing suitable small-scale machinery for use by the fruit preservation industry. There are practically no organization in this country which can take up this challenge. To depend on other countries for this is not desirable. The CFTRI probably with collaboration with Central Mechanical Engineering Research Institute, Durgapur (CMERI) and similar organizations, which have got necessary resources and personnel, should take up this challenge and set up cells where such small and prototype units could be built up so that they could serve as models for the larger machine manufacturers. This aspect of designing and building up of small machines is of universal application in India, not only in the fruit preservation industry, but also in other small scale industries. A small beginning has, however, been made in this direction at CFTRI, where efforts are being made to design and fabricate small prototype units such as grader, washer, through-flow-drier, spin pasteurizer, etc. which are required by the industry. There is, however, great need as well as scope for expanding this activity in collaboration with machinery manufacturers in the country. The benefit that could acrue from this activity can be far-reaching in the long run as regards the development of small-scale industries, including fruit and vegetable processing industry.

Research and advice

The fruit and vegetable preservation industry, as it exists today in this country, cannot afford to employ highly qualified technical and advisory personnel in every one of the units. It is, therefore, necessary to have a panel of experts with considerable experience in the field who will be in a position to render effective and timely advice to the industry. Such an agency (panel) does not exist in the country except for occasional help and advice by institutions such as ours at CFTRI. I believe that an agency like the Campden Fruit and Vegetable Preservation and Quick Freezing Research Station in UK which is partly financed by the Government and partly through subscription from members in the fruit and vegetable preservation industry, would be useful in this country also. Campden does everything necessary for the industry at every stage by undertaking *ad hoc* research—fundamental research, technical and advisory work, quality control work, etc. This has proved highly beneficial in building up the fruit and vegetable preservation industry in UK. It has built up such a high reputation that the fruit and vegetable preservation industry in UK has complete faith and confidence in its work, and it is a mutual one. There are such similar organizations in some other countries also. I referred to Campden on account of my long and continued association with it. I am of opinion that such a set-up in our Institute working entirely for the benefit of the fruit and vegetable preservation industry would be of great value in creating a sense of mutual faith and confidence between the laboratory scientist and the industrialist. The 15-year Perspective Plan of the CFTRI envisages the establishment of a full fledged Fruit and Vegetable Technology Institute, along with similar institutions in other fields of food technology, wherein the work mentioned earlier could be taken up with great advantage to the benefit of the industry.

Extension and publicity

The ultimate success of any manufacturing industry depends largey upon the sale of the manufactured goods. In the case of food industry such as fruit and vegetable preservation industry, where the consumers are highly resistant to changes in food habits, it is necessary to have a proper agency to make known the good points of the products and to publicize their value not only within the country, but also in other parts of the world where there is likely to be a demand for such products. To popularize the Indian fruit and vegetable products in other countries, it is necessary to have suitable agencies to take up this work. The industry at its present stage of development, can not be in a position to finance this work entirely. The government, through its Embassies, Consulates and other contacts in foreign countries, can be of much use in this direction. These agencies can be of assistance in popularizing the Indian products through exhibitions, trade fares, business organizations, social contacts, etc. Suitable advertizing material in the form of posters, samples, literature, etc. would be necessary for this. Further, in order to ensure that the products might compete favourably with similar products in those countries, it may be necessary to give certain facilities such as making available important raw materials like sugar, tin containers, etc. at world prices, and also by giving adequate freight concessions by road, rail and sea. Such assistance is necessary in the earlier stages to foster and develop the industry to its full and independent stature. With such help and encouragement, this industry, which is coming up fairly quickly, can become one of the major industries

with its benefits channelling through to several sectors of economic development in the country.

Utilization of wastes from preservation factories

Large quantities of wastes from the fruit and vegetable preservation factories are not being fully exploited in spite of the fact that they can serve as highly valuable raw materials for secondary industries. Wastes from pineapple canning factories, citrus pomace and peel, apple pomace from juice and cider units, pea hulls, tomato skin and seeds, mango peels and stones, etc. can be profitably employed for the recovery of useful materials such as sugar syrup, pectin, starch, animal feeds, etc. as is being done in other parts of the world. The importance of utilization of wastes for by-products for the success of any processing industry, cannot be over-emphasized. For instance, in the Hawaiian Pineapple Canning Industry, every part of the pineapple plant is utilized profitably through development of valuable by-products from waste materials. The juice from the pineapple peel and core is suitably treated with ion exchange resins and the resulting liquid is concentrated to a sugar syrup which is subsequently utilized in the canning of pineapple itself. The syrup thus obtained replaces nearly 50 per cent of the sugar utilized by the industry which indicates the great value of recovery of useful materials from wastes. It has been reported that this single item alone accounts for the major portion of the profits of the pineapple canning industry. In Hawaii, it is humorously remarked that what is lost from the Hawaiian Pineapple Canning Factories is only the peal of the engines. Intensive investigations in this direction is urgently needed as the efforts are likely to result in adding to the profits of the industry, thereby helping to reduce the present high cost of the preserved products in the country. This aspect of work is, therefore, one of the urgent requirements of the fruit and vegetable processing industry.

Prevention of loss in fresh fruits and vegetables

India produces nearly 16 million tons of fruits and vegetables and it is often reported that nearly 30 per cent of this is lost due to lack of proper handling and transport facilities. This enormous waste of valuable material would be minimized to a large extent by employing modern technological methods. One of this, I have dealt with earlier, is the development of suitable processed products from the fresh raw materials, but this only accounts for about 0.3 per cent or so. A still more effective approach would be to adopt improved methods of packing, handling and transport, such as pre-packaging in smaller units, employment of the right type of packaging materials, installation of a chain of suitably controlled stores and warehouses, in different parts of the country, etc. In other countries, this system has become highly important so that the loss of fresh fruits and vegetables has been reduced to as low as 5–10 per cent. The prevention of loss of this valuable protective foods would go a long way in meeting to some extent the food needs of the country, and as such every effort has to be made to intensify research and development in this direction. A small, but highly useful beginning, has already been made in this direction in our Institute. There is still great scope for expanding this activity in collaboration with the various agencies concerned. Improved methods of packaging, handling and storage would be beneficial in the case of fruits such as banana, mango, grape, orange, etc. which are in great demand in other countries. Recent efforts in this direction as in the case of export of

bananas to Italy and Russia and of oranges and grapes to Japan and other countries in South and South East Asia, have indicated the great scope for such an enterprise. More intensive effort and on a large-scale is now needed to follow this up. The CFTRI and other research institutions, as well as government agencies, can play a vital role in this direction.

There are some of the major requirements and steps that are to be taken, for the rapid development of the fruit and vegetable processing industry in the country. There may, however, be still some others, of varying urgency and importance. If sufficient encouragement and help is given, it is sure to make a mark as a contributory factor in the economic development of the country.

Proteins, Especially from Oilseed Cakes and Coconut Cake

(Miss) RADHA KARNAD
Directorate General of Health Services
New Delhi

It is now generally recognized that the diets consumed by a large majority of the population in this country, especially in the low socio-economic groups, are deficient in essential nutrients such as proteins, vitamins and minerals. The consequences of these deficiencies are strikingly seen in the case of the vulnerable segments of the population. Nutritional surveys carried out in the country have shown that protein malnutrition (Kwashiorkor) and diseases due to deficiencies of vitamin A, B complex, calcium and iron are widely prevalent especially among growing children and expectant and nursing mothers. Protective and protein rich foods like milk, meat and eggs are not available in sufficient quantities in the country and further are not within the reach of the low-income groups. There is, therefore, an urgent need for large scale production of low cost protein supplements from available protein-rich indigenous raw materials and fortifying them with vitamins and minerals. These protein-rich foods can be used as a supplement for making up the deficiencies in the poor dietaries and also for the treatment and prevention of protein malnutrition in the country.

Protein-rich foods from oilseed meals

The protein-rich foods available in the country are the various edible oilseed meals and pulses. Out of the oilseed meals, groundnut meal is available in fairly large quantities, while sesame meal (*Sesamum indicum*) is available only in moderate amounts. Data regarding the annual production of groundnut, sesame and Bengalgram is given in Table 1. Low fat groundnut meal has a protein content of about 50 per cent while low fat sesame flour contains 37 per cent protein and Bengalgram dal has a protein content of 24 per cent. The chemical composition of Bengalgram dal and low fat groundnut and sesame flours is given in Table 2. However, in

Table 1—Annual production of groundnut, Bengalgram and sesame seed

	Production* for 1964–65 (1,000 tonnes)
Groundnut (in shell)	6,176
Bengalgram (whole pulse)	5,763
Sesame seeds	466

*Figures taken from the All-India Final Estimates issued by the Economic and Statistical Adviser in the Ministry of Food and Agriculture, Government of India.

Table 2—Chemical composition of Bengalgram dal and low fat groundnut and sesame flours

	Bengalgram dal	Low fat groundnut flour	Low fat sesame flour
Moisture, %	10.8	10.1	10.3
Protein (N×6·25), %	24.0	50.2	37.2
Fat, %	4.5	9.2	12.5
Crude fibre, %	0.4	0.6	4.2
Carbohydrate (by diff.) (g.)	57.5	25.4	28.6
Ash, %	2.8	4.5	7.2
Calcium, %	0.09	0.08	2.30
Phosphorus, %	0.33	0.52	0.66
Vitamin B_1 (mg.), %	0.38	1.06	1.05
Riboflavin (mg.), %	0.15	0.22	0.21
Nicotinic acid (mg.), %	2.2	16.8	2.7

Table 3—Amino acid composition of certain protein-rich foods of vegetable origin as compared to milk proteins

(Calculated at 16.0 g. of nitrogen)

Amino acids	Bengal-gram	Soya-bean flour	Ground-nut flour	Sea-same flour	Cotton-seed flour	Coco-nut flour	Sun-flower seed meal	Milk protein
Arginine	6.9	7.3	11.3	8.7	11.3	10.8	8.2	4.2
Histidine	2.3	2.9	2.1	1.5	2.7	1.6	1.7	2.6
Lysine	6.4	6.8	3.0	2.8	3.5	3.0	3.8	8.6
Tryptophan	0.6	1.4	1.0	1.8	1.3	1.0	1.3	1.5
Phenylalanine	5.0	5.3	5.1	8.0	6.0	3.9	5.0	5.5
Methionine	1.7	1.7	1.0	3.2	1.7	1.5	2.9	3.2
Threonine	4.8	3.9	1.6	4.0	3.0	2.9	3.9	4.7
Leucine	8.0	8.0	6.7	7.5	6.0	7.9	6.4	11.0
Iso-leucine	4.0	6.0	4.6	4.8	5.3	4.7	5.2	7.5
Valine	5.4	5.3	4.4	5.1	5.3	4.9	5.4	7.0

some respects, sesame flour due to the presence of methionine in which groundnut meal is deficient. But sesame meal has a slightly bitter taste and hence can be used only in limited amounts in the diet. Bengalgram dal (*Cicer arietinum*) is a pulse available at a moderate cost and is already being consumed widely in the diet. The proteins of Bengalgram are particularly rich in the essential amino acid, lysine, in which both groundnut and sesame meals are somewhat deficient. Coconut meal is also another nutritious supplement which is rich in lysine and also contains methionine. Table 3 gives the amino acid composition of protein-rich oilseed meals available in the country, and also that of Bengalgram, as compared to milk protein. Soyabean is not being grown in India at present in any appreciable quantity. However, oilseeds and pulses are available in the country. Keeping in view of the amino acid composition of these foods, it should be possible to evolve a nutritious food supplement from combination of one or two oilseed meals and Bengalgram, by suitable blending and fortifying with essential vitamins and minerals.

Researches carried out at CFTRI

The CFTRI, Mysore have been carrying out extensive investigations in this direction, in order to find out a suitable composition for preparing a multipurpose food which will be most acceptable to the people. Four different compositions were prepared, using different proportions of low fat groundnut meal, low fat sesame meal, Bengalgram dal and black gram dal. The multipurpose food samples corresponding to these compositions were prepared and their acceptability was compared by a panel of tasters from the CFTRI and Indian Institute of Science, Bangalore. As a result of these organoleptic tests, it was finally accepted that MPF containing three parts defatted groundnut flour and one part roasted Bengalgram dal was most acceptable and was, therefore, adopted for large scale preparation. However, since this food is deficient in essential vitamins and minerals, the product was fortified with calcium phosphate, thiamine, riboflavin and vitamins A and D. The vitamins were added in the form of pre-mix after being mixed with a small quantity of groundnut flour. This nutritious food supplement contains 41.9 per cent protein, 8.5 per cent fat and 35.8 per cent carbohydrate and has a calorie value of 387 per hundred grams. The chemical composition of Indian multipurpose food is presented in Table 4.

Feeding trials with Indian multipurpose food

As a result of consumer acceptability trials carried out with Indian MPF, it has been found that the seasoned product can be incorporated at levels ranging from 5 to 25 per cent in various popular savoury preparations used in the daily diet such as dal, vegetables, *chapaties*, etc. for enhancing the multihir value of the diet. The unseasoned MPF could also be used in the same proportion in the various sweet preparations, based on cereals, and also for fortifying porridge, puddings and sweet dishes suitable for feeding children. Due to its versatility and low cost and easy adoptability in the Indian dietary, Indian MPF was used for carrying out feeding

Table 4—Chemical composition of Indian and American multipurpose foods

(value per 100 g.)

Constituent	Indian multipurpose food	American multipurpose food
Moisture (g.)	6.8	6.7
Protein (N×6.25) (g.)	41.9	42.3
Fat (g.)	8.5	7.6
Ash (g.)	7.0	6.5
Carbohydrate (by diff.) (g.)	37.8	36.9
Calcium (g.)	0.665	0.587
Phosphorus (g.)	0.820	0.440
Iron (mg.)	5.1	7.0
Thiamine (mg.)	1.3	0.7
Nicotinic acid (mg.)	14.0	7.0
Riboflavin (mg.)	3.0	1.2
Vitamin A (IU)	3000	2940
Vitamin D (IU)	300	235
Calorific value	387	386

trials in institutions, schools and also for child feeding programmes. The feeding trials carried out in institutions by the CFTRI have shown that one to two ounces of Indian MPF can be effectively used as a protein supplement for making up the deficiencies in the diet and also for combating protein malnutrition among children. One ounce MPF would cost about 6 paise according to the present cost of foodstuffs. However, the cost was much lower when it was first evolved.

Consumer feeding programmes under the auspices of the Meals for Millions Association of India

The valuable work carried out at the CFTRI has to be applied in the field, so that the large majority of people whose dietary is deficient in proteins should be benefited. It was with this objective in view that the Meals for Millions Association of India, whose main aim is to relieve malnutrition in the country, started extensive feeding programmes in different parts of the country through institutions, schools and hospitals. There was considerable reluctance in the use of MPF in the initial stages and some people looked down upon it by estimating it as cattle feed; the popularization of this food, therefore, required a great deal of effort, tact and persuation for its use in the Indian dietary.

A large number of feeding programmes were carried out with the help and cooperation of medical practitioners, paediatricians in hospitals, and heads of children's institutions, and also with the cooperation of the scientists from the CFTRI. In this connection mention may be made of the encouraging results obtained by the Association. Particular mention may be made of the trials carried out in the Ankola District of Mysore State with preschool and school children. Children of the age-group 2–6 and 7–12 years, both boys and girls, were selected and divided into two groups on the basis of their initial height and weight. One group received their usual diet, serving as the control and the other received a daily one ounce supplement of Indian MPF. The feeding was continued for a period of six months. Measurements of height, weight, RBC count and haemoglobin content were made both at the beginning and at the end of the experiment. The children were also assessed for their nutritional status. From the results (Table 5) it was clear that the children receiving the supplement of Indian MPF improved significantly in their nutritional status and showed improvements in height, weight, RBC count and haemoglobin contents over the control. On an average, the gain in weight of children was about 3 to 4.5 pounds. Similar feeding trials have been carried out in other children's institutions. The results have shown that MPF is acceptable and causes no digestable troubles. Most of the children gained in weight within a period of three to six weeks when given the supplement over and above the usual diet.

Multipurpose food in school lunch programmes and homes

With the cooperation of housewives, MPF has been tried in simple household recipes, such as *chapaties*, dal, vegetable, etc. in several homes. Due to its versatility, MPF can be incorporated in a variety of preparations used in the daily diet. It can also be used in bakery biscuits in the proportion of 10 to 20 per cent. MPF can, therefore, be used with advantage in school lunch programmes as porridge with skim milk powder or in snacks such as biscuits, barffi and chikki.

Table 5—Results of the feeding experiments with Indian multipurpose food (1 oz. of MPF) as a supplement per day on the growth and nutritional status of children at Ankola

[Total no. of girls in: (1) Control group: 2–6 years of age, 40; 7–12 years of age, 16; (2) Experimental group: 2–6 years of age, 63; 7–12 years of age, 28. Duration of the experiment, 6 months]

	Girls between the ages of 2–6 years						Girls between the ages of 7–12 years					
	Control group			Experimental group			Control group			Experimental group		
	Initial	Final	Diff.	Initial	Final	Diff.	Initial	Final	Diff.	Initial	Final	Diff.
Height, in.	36.60	38.20	1.60	35.80	37.71	1.91	49.82	51.23	1.41	47.98	49.58	1.60
Weight, lb.	27.43	28.92	1.49	26.11	29.37	3.26	47.60	48.79	1.19	45.31	49.98	4.67
Haemoglobin, g.%	8.67	9.45	0.78	8.76	11.30	2.54	9.61	9.87	0.26	9.34	11.95	2.61
Total nutritional score	2.60	1.80	0.80	2.80	1.20	1.60	2.60	2.40	0.20	3.70	1.50	2.20
CHANGES IN NUTRITIONAL STATUS												
Improved	—	10	—	—	39	—	—	—	—	—	20	—
Stationary	—	29	—	—	24	—	—	14	—	—	8	—
Deteriorated	—	1	—	—	—	—	—	2	—	—	—	—

Protein biscuits—'Nutro'

Due to the need for a ready to eat snack rich in proteins for school lunch programmes, the formula for 'nutro' biscuits was evolved at the CFTRI. At present they are being made by one of the largest biscuit manufacturers in the country and are known as 'Nutro biscuits'. These biscuits are enriched with processed groundnut flour and have thrice as much proteins as ordinary biscuits (about 15 per cent protein), a significant fact in view of the protein malnutrition prevalent in the country. They have a calorie value of 105 per ounce and are also fortified with essential vitamins and calcium.

It may be mentioned in this connection that it was our late Prime Minister, Pandit Jawaharlal Nehru, who first contributed a lakh of rupees from his relief fund for making Nutro biscuits for distribution to children in flood and famine affected areas, and which encouraged the Association in expanding the feeding trials with these protein biscuits.

MPF and Nutro biscuits in diet therapy in cases of nutritional oedema syndrome

Several workers have successfully treated cases of nutritional oedema syndrome (Kwashiorkor) by oral administration of various types of protein supplements. Mention may be made here of soyabean and ripe banana used by Dean, cooked Bengalgram flour by Venkatachalam and Indian MPF formula C (containing skim milk powder) by Subrahmanyan.

Investigations were carried out using Nutro biscuits in the diets of children suffering from protein malnutrition, at the Government Stanley Hospital, Madras, under the guidance of its Dean and the Director of Medical Services, Madras. Eighty-two children suffering from malnutrition

in the paediatric wards of this hospital were given Nutro biscuits. The children were between the age-group of 6 months to $1\frac{1}{2}$ years; $1\frac{1}{2}$ – 3 years; and 4–11 years. The feeding was continued for a period of 6 weeks. From the results it was seen that the children improved in health as a result of the protein from the biscuits which were given in place of skim milk. The symptoms of protein malnutrition gradually subsided and the children gained in weight. It was further seen that the biscuits were readily accepted by the children and were easily digested and had no adverse effects, and, therefore, might be used as a prophylaxis against protein malnutrition.

Mention may be made of two cases of children affected with protein malnutrition with symptoms of oedema, skin pigmentation, anorexia and diarrhoea. One of the subjects showed enlarged liver and sparse reddish hair. The children were given a diet which provided 40 calories and 4 g. of protein per kilo of body weight per day. The protein in the diet was derived mainly from Nutro biscuits. The oedema began to diminish and gradually subsided in about 5 weeks. The skin lesions healed in about 7–8 weeks and the children improved in their general condition and put on weight. The serum protein and the albumin content also increased at the end of the treatment (Table 6). The albumin content which was as low as 1 per cent on admission, went up to 3.2 per cent after treatment in one of the subjects. It may be mentioned in this connection that normally cases of protein malnutrition in the hospital were treated with skim milk powder and these cases were available for comparison. It was found that both as regards final results as well as time required for improvement, Nutro biscuits compared favourably with skim milk powder. These results have opened up possibilities of using vegetable protein supplements in diet therapy when skim milk powder is in short supply in the country.

Today multipurpose food is used in several hospitals in the country as a high protein diet supplement in cases of protein malnutrition and also for distribution in the O.P.Ds. The reports from these hospitals indicate that the children improved remarkably in health as a result of these supplements, even though they were in the hospital for a short period: As one of the paediatricians has put it, "The child is a different human being and his as well as his parents' outlook and attitude to lie has changed completely". Another interesting report from one of the hospitals states: "The children showed gain in weight and change in the mental attitude. Their irritability, lethargy and peevishness was much less. The child became more interested in the environment and had better attitude towards strangers, better appetite and started giving a smile when offered toffee or coin". One of the medical practitioners has also used the food successfully as a high protein diet for tuberculosis patients, laprosy patients and malnourished children with symptoms of tawny hair, flabby muscles and gross weight deficiency.

Table 6—Serum protein content of subjects before and after treatment with Nutro biscuits

Serum proteins	Before treatment		After treatment	
	Initial	Final	Initial	Final
Total protein (%)	3.24	5.48	4.28	6.56
Albumin (%)	1.00	3.20	2.28	4.28
Globulin (%)	2.24	2.28	2.00	2.28

In another case it is stated that "the cases of high blindness, skin diseases, and rickets improved considerably and the children gained in weight".

The above results have indicated that processed oilseed cakes can be used with advantage as a source of protein supplement, especially for child feeding programmes. They can also be used for supplementing the diet of industrial workers through canteens which would undoubtedly improve their diet and also their industrial output.

Paneer-like product from coconut protein

As already mentioned earlier, coconut protein contains the amino acid, lysine and also methionine. Some experiments have been carried out at the CFTRI for preparation of paneer from coconut milk, from which the fat has been removed. The ripe kernels are pressed in a screw press and the milk obtained centrifuged to remove the fat. The skim milk containing the coconut protein is heat coagulated and the coagulates recovered from the whey by centrifugation. The wet coagulate is pressed into discs and autoclaved. This produces the necessary texture. After autoclaving and cooling, the blocks are pressed in a basket press to remove the excess water and cut into cubes. These can be used for preparation of curry in the usual manner. The curry can be canned, sterilized and preserved as a ready to serve preparation.

Processed oilseed cake proteins for preparation of weaning foods for infants

One of the most important public health problems facing the country today is protein malnutrition prevalent among toddlers and pre-school children of the age-group 1–6 years, especially during the weaning period. Nutrition surveys conducted during the years 1956–59 in four States of South India, with over 45,000 children under five years of age have shown that Kwashiorkor (a dietary disease due to protein malnutrition) and Marasmus (emaciation) were observed in 2 to 3 per cent of the children and general protein malnutrition in 5 to 25 per cent of the children. About 5 to 15 per cent of the admissions in children's hospitals were cases of severe protein deficiencies. On the whole it may roughly be assessed that out of a total population of about 80 million pre-school children in the country, at least 10 to 15 million are victims of protein-calorie-under nutrition and also vitamin and mineral deficiencies. The wide prevalence of protein malnutrition has been traced to faulty feeding of the child after weaning, due to poor economic condition of the parents and ignorance of the mother of correct methods of feeding the children. Foods containing protein of high biological value such as milk, are not within the reach of the low-income groups and, therefore, the child after weaning is switched on to the adult diet, which consists mostly of carbohydrate foods. It may be mentioned that if proper nutrition is not given to the child at this critical period of this life, irreparable damage to health is caused in later life. There is, therefore, an urgent need for an alternative protein supplement from available vegetable protein resources in the country which can be used for the preparation of weaning food for children, till the milk shortage in the country improves.

Weaning food

The acute shortage of milk in India and the dwindling supplies of skim milk powder from the surplus dairying countries, necessitates the development

of food combinations based on readily available oilseed meals and legumes. Various processes have been developed at the CFTRI for the preparation of a pre-cooked protein food, suitable for feeding weaned infants and young children. One of these foods is made from a blend of flours obtained from good quality groundnut cake, puffed Bengalgram (chick-pea), lightly roasted green gram (*Phaseolus mungo*), dried peas and parboiled rice, mixted with sugar, common salt and a premix of vitamins and minerals. The food is made in pre-cooked and ready to eat form. The product is crisp and yellowish in colour. It may be given to infants by reconstituting in about six times its weight of hot water and sweetened with sugar, in the form of porridge (similar to that obtained with rolled oat flakes). A daily supplement of 50 g. of the product costing about 12–15 paise will provide nearly half the daily requirements of proteins, vitamins and minerals of weaned infants and young children. The product contains 35 per cent protein and is fortified with essential vitamins and calcium. The cost of the packed product comes to about Rs 2.50 per kg.

Production of infant foods based on peanut flour

Another type of weaning food evolved at the CFTRI is prepared from gelatinized wheat, peanut flour and skim milk powder, with the addition of hydrogenated groundnut oil and mineral salts and fortified with vitamins. It is prepared by the spray dried process. The protein content of the food is 25 per cent (54 per cent of this is derived from groundnut, 36 per cent from milk and 10 per cent from cereals). Animal experiments have shown that the protein efficiency ratio of this food is 2.5 as such and 2.8 when fortified with DL-methionine. The PER of milk at the same level is 3.0. The infant feeding trials with this food are in progress at Vellore.

With the advance of science and technology more and more use should be made of proteins from oilseed cakes and pulses to make up the deficiency of proteins from animal sources. The processed foods prepared from these vegetable protein foods should find a place in child feeding programmes. They should be prepared on a large scale at low cost and made available to the low income groups for feeding children.

Large scale production of processed groundnut flour and Indian multipurpose food

The present production of Indian multipurpose food is not enough to meet the demands of the whole country. The multipurpose food produced by the two-ton unit at the CFTRI, and the multipurpose food plant installed by the Chandra Corporation at Coimbatore is mostly used for institutions feeding programmes. The production should, therefore, be considerably expanded. This can be done in collaboration with the oil industry in the groundnut producing areas, so that the expenses for the installation of expeller and related items of equipment can be avoided and the whole process can become a profitable concern. In order to ensure pure groundnut flour, free from aflatoxin, the groundnuts are first graded, roasted, decuticled and subjected to hand-picking to remove fungus attacked kernels, and are then sent to the oil mills for expeller treatment to remove the oil. The cake thus obtained is powdered to the required degree of fineness and mixed with roasted Bengalgram flour and fortified with synthetic vitamins and calcium. The whole process is simple and can be carried out with the aid of equipment such as mixers and grinders which can be assembled in the country at one of the firms in Bangalore, and so does not

require any foreign exchange. With the technical guidance of the CFTRI, I am sure, the State Governments can instal units for production of multi-purpose food which can be used for child feeding programmes. The two UNICEF 10-ton plants installed at Coimbatore and Bombay can also help in meeting the demands of pure groundnut flour, which can be used for manufacture of Indian MPF and also for fortifying bakery products. Early steps should, therefore, be taken for the working of these plants to full capacity.

Conclusion

Due to the acute shortage and high cost of protein-rich foods from animal sources such as milk, meat and eggs, and the dwindling supplies of skim milk powder from the surplus dairying countries, protein rich foods based on a combination of oilseed meals and legumes should be prepared on a large scale from available food resources in the country and widely popularized for supplementing the diet of the people, especially the vulnerable groups, which is deficient in proteins and other essential nutrients.

As a result of extensive investigations carried out at the CFTRI, a low cost, versatile and nutritious food supplement, known as 'Multipurpose Food' has been evolved, using three parts of processed groundnut flour and one part of roasted Bengalgram flour, fortified with essential vitamins and minerals, and its consumer acceptability has been established.

Consumer feeding programmes with Multipurpose Food and Nutro biscuits have been carried out by the Meals for Millions Association of India on an extensive scale in different parts of the country through schools, residential institutions and hospitals, for improving the health and nutritional status of malnourished children. Field studies have also shown that MPF can be successfully used as a protein supplement for meeting the protein deficiency in the Indian dietary. Scientific feeding trials with school children carried out by the Association have further established the fact that supplementing the daily diet of undernourished children with half an ounce to one ounce of MPF produced a remarkable improvement in their growth and nutritional status. Further, MPF and Nutro biscuits have been successfully used in Diet Therapy in hospitals for treatment of cases of nutritional oedema in children.

It is suggested that these vegetable protein foods be produced on a large scale from indigenous food resources in the country, and used for child feeding programmes for improving their health. Processed oilseed meals and legumes should also be utilized for the preparation of weaning foods for infants and made available to the low-income groups, with a view to relieve protein malnutrition in the country.

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Fuel Economy in Sugar Industry

S. C. GUPTA
National Sugar Institute
Kanpur

Sugar Industry is the second largest agro-based industry in the country. The year which has just ended has recorded the highest sugar production so far, viz. 32.5 lakhs tonnes. Now we are in a position to export white as well as raw sugar after meeting our internal demand. During the last 1964–65 season 204 sugar factories worked in the country.

Bagasse, which is one of the by-products of the sugar industry is at present utilized by the sugar factories as fuel. Not only this, many factories are using extra fuel such as coal, wood, furnace oil in addition to the bagasse produced by them. Bagasse is, however, an ideal raw material for the manufacture of paper and newsprint, it would be in the fitness of things if the maximum possible quantity of bagasse is utilized for paper manufacture. Thus, there is need not only for eliminating extra fuel consumption but also saving bagasse for paper manufacture.

In this context scope for fuel economy in the Indian sugar industry is discussed below :

Fuel resources of the sugar industry — bagasse production

The Cane Sugar Industry has the unique advantage of finding its fuel requirement for the manufacture of sugar from its own raw material in the form of bagasse, the residue that is left after sugarcane is crushed. The production of bagasse varies in different parts of India due to variation in the fibre content of cane. The percentage and total bagasse production in different regions in India during 1959–60 is given in Table 1.

Extra fuel consumption

Table 2 gives the percentage and total extra coal, wood, furnace oil, etc. used in different regions in India during 1959–60. The position now is not much different from 1959–60. It will be seen from Table 2 that the annual extra fuel consumption is of the following order :

1,08,202 tonnes of coal
2,05,314 tonnes of wood
26,590 tonnes of furnace oil

Total fuel used in terms of bagasse

The total fuel used in terms of bagasse in the different regions in India (maximum, minimum and average) is given in Table 3.

Table 1—Percentage and total bagasse production in different regions in India

Region	Fibre % cane	Bagasse % cane	Total bagasse production (tonnes)
Punjab	15.20	32.31	3,61,349
West U.P.	15.26	33.31	20,75,319
Central U.P.	16.62	35.59	9,25,467
East U.P.	16.60	35.09	13,91,518
Bihar	17.13	36.28	12,69,348
West Bengal	16.33	33.38	31,866
Assam	12.60	27.49	16,106
Orissa	13.62	29.24	8,940
Maharashtra	12.35	25.76	8,72,886
Gujarat	13.05	26.28	23,082
Andhra Pradesh	12.62	27.22	3,85,494
Madras	14.16	29.65	2,72,319
Mysore	12.35	27.24	2,23,922
Kerala	12.55	26.19	31,729
Madhya Pradesh	15.55	32.08	94,481
Rajasthan	13.69	30.24	42,662
ALL-INDIA	15.16	32.38	80,26,488

Table 2—Percentage and total extra fuel consumed in different regions in India

Region	Coal		Wood		Furnace oil	
	% Cane	Total (tonnes)	% Cane	Total (tonnes)	% Cane	Total (tonnes)
Punjab	0.240	2,647	0.215	2,404	—	—
West U.P.	0.521	32,441	0.516	32,130	—	—
Central U.P	0.213	5,539	0.480	12,482	—	—
East U.P.	0.301	11,897	1.182	46,873	—	—
Bihar	0.630	22,042	0.442	15,394	—	—
West Bengal	0.050	44	0.070	62	—	—
Assam	0.320	188	2.020	1,186	—	—
Orissa	—	—	6.430	1,966	—	—
Maharashtra	0.453	15,350	1.160	39,307	0.740	25,195
Gujarat	1.230	11,084	0.840	740	—	—
Andhra	0.310	4,339	0.870	12,310	—	—
Madras	0.001	11	0.340	3,107	0.108	998
Mysore	0.320	266	1.610	13,209	0.050	396
Kerala	—	—	—	—	—	—
Madhya Pradesh	1.490	4,388	1.590	4,683	—	—
Rajasthan	0.748	1,055	6.122	8,637	—	—
ALL-INDIA	0.515	1,08,202	0.807	2,05,314	0.107	26,590

Table 3—Total fuel consumption in sugar factories in terms of bagasse per cent cane

Region	Total fuel used in terms of bagasse % cane			Total (tonnes)
	Maximum	Minimum	Average	
Punjab	34.00	31.72	33.10	3,70,210
West U.P.	42.96	30.63	35.27	21,96,583
Central U.P.	61.20	33.35	36.72	9,39,990
East U.P.	43.69	32.03	37.31	14,79,851
Bihar	55.44	29.97	38.40	13,43,697
West Bengal	33.58	33.58	33.58	32,054
Assam	30.82	30.82	30.82	18,059
Orissa	37.28	37.28	37.28	11,397
Maharashtra	37.79	22.05	32.07	10,86,370
Gujarat	31.45	29.58	37.73	26,718
Andhra Pradesh	32.00	26.26	29.07	4,11,728
Madras	32.37	25.87	30.61	2,81,223
Mysore	46.82	23.66	29.57	2,43,080
Kerala	26.19	26.19	26.19	31,729
Madhya Pradesh	50.69	31.84	37.79	1,11,306
Rajasthan	33.35	36.92	38.61	27,233
TOTAL			35.33	87,11,465

It will be observed that there is great variation in the figure of fuel consumption. While there are factories with a total fuel consumption in terms of bagasse of as low as 24–26 per cent on cane, there are factories also consuming as much as 45–50 per cent in terms of bagasse per cent cane. These differences have to do with the size of plant, the equipment, operation and product quality.

It is well known that thc Indian sugar industry expanded suddenly after protection without adequate thought to the location, size or equipment. Most of the units were small (300–600 tons) and steam driven. Several of them were not balanced in respect of fuel and steam. Most of the factories have since expanded and in several cases the expansions have been haphazard resulting in further imbalance of steam and fuel.

Minimizing fuel consumption in sugar factories

Equipment design, manufacturing technique and product quality, have made very rapid advances during the last few decades. Efficiency in the use of fuel has been achieved by:

(a) reduction of moisture in bagasse by better milling;

(b) improved furnaces with forced and induced draughts ensuring maximum combustion efficiency;

(c) high pressure boilers with water walls, super-heaters, adequate heat recovery systems like economizers and air pre-heaters;

(d) adequate instrumentation for scientific control of boiler operation.

While the old boilers have efficiencies below 50 per cent, efficiencies with improved generation equipment of the order of 65 have been achieved without difficulty. In some cases even higher efficiencies of the order of 68 per cent have been recorded.

In the matter of steam utilization and heat conservation also, there have been several advances, such as: (1) Semi-electrification with efficient turbo-alternators using high pressure steam and generating the power needs of the factory with a fraction of the total steam requirements and where necessary, even making considerable by-products power available; (2) Thorough lagging and insulation of all the heating surfaces as well as closed condensate systems ensuring maximum return of heat to the boilers in the form of hot condensate; (3) Improved and continuous process equipment, such as, high velocity juice heaters, continuous liming and sulphitation systems, continuous clarifiers, rotary vacuum filters, multijet condensers, high speed centrifugals with superheated wash water or super-heated steam for drying sugar, etc.; and (4) Great reduction in process steam requirements by utilization of vapours for juice-heating and pan-boiling; such as vapour, line juice heater, bleeding from the first and second bodies of the evaporator for juice heating and bleeding vapour for pans from the first body of the evaporator or preferably from a separate vapour cell.

Other improvements that have contributed to better fuel economy and steam conditions as well as greater throughput from the same equipment are:

(i) Automatic bleeding of live steam into the exhaust;

(ii) Maintenance of steady pressures on the juice-heaters and evaporators by the use of surplus or over-flow valve;

(iii) Maintenance of steady vacuum conditions by the use of independent multijet condensers or vacuum boosters.

The process of making white sugar by the carbonation and sulphitation processes have also undergone considerable improvements, particularly in the boiling house resulting in better product quality. The straight three massecuite system with single curing and production of small grain has given place to considerable low grade melting double curing of all grades and bold grain production. Such low grade melting and bold grain production result in increased steam consumption, the massecuite per cent cane has increased in many cases from about 35 to above 45 per cent very often reaching 48 per cent. While the steam consumption in a number of older plants is as high as 80–90 per cent, the steam consumption in some of the recent installations has been considerably below 60 per cent in sulphitation factories and between 60–65 per cent in carbonation factories. It is, therefore, possible to achieve a steam consumption of about 60 per cent and fuel consumption in terms of bagasse of about 26 per cent. Some of the carbonation factories with a large percentage of bold grain production may require up to 28 per cent bagasse on cane.

Scope for saving fuel in Indian sugar factories

In the light of the above discussions, the possibilities of fuel saving in the sugar industry would be as given in Tables 4 to 6.

It will be observed from Table 6 that it is possible to save 1,00,957 tonnes of coal, 1,94,251 tonnes of wood and 11,013 tonnes of furnace oil.

There is also the possibility of saving 12,12,203 tonnes of bagasse. The possibilities of saving bagasse are greater in Uttar Pradesh, Bihar and Punjab where the cane has a higher fibre content and bagasse production is correspondingly high. While saving of coal and fuel oil would release the same for other industries, the saving on wood would stop the drain on the forest resources. Factories in Maharashtra and other regions where bagasse production is less than 28 per cent would use lesser quantities of coal, wood and furnace oil than at present when they become more efficient. It may be observed from Table 5 that even in those regions where bagasse production is deficient there is further scope for saving fuel if the factories in those regions consume not more than 28 per cent bagasse on cane.

Saving of bagasse. It will be observed from the above that very large quantities of bagasse can be saved. The importance of this saving has become great recently with the utilization of bagasse for paper and board industries. Actually bagasse is being considered too valuable a raw material to be burnt as fuel. Projects have been started in which the entire bagasse production has been replaced by coal or fuel oil for purposes of paper production. A sugar factory consumed a lot of fuel and entire replacement of bagasse with alternate fuel would mean increasing the strain on the fuel resources as well as on the transport system, which are not in a very happy position at present in view of the intense pressure from expanding and multiplying industries. Before, therefore, thinking of increasing the number of projects based on complete replacement of bagasse fuel, it would be desirable to examine the possibilities of starting projects on saved bagasse in areas where much savings are possible, such as in U.P. and Bihar. Perhaps some of the projects based on complete replacement will have to be very near the collieries or refineries. These could be located in a number

Table 4—Scope for saving fuel on the basis of 28 per cent bagasse consumption

Region	Bagasse produced		Target requirement		Estimated savings (tonnes)			
	%Cane	Total (tonnes)	%Cane	Total (tonnes)	Bagasse	Coal	Wood	Furnace oil
Punjab	32.31	3,61,349	28.00	3,13,107	48,242	2647	2,404	—
West U.P.	33.31	20,75,319	"	17,43,469	3,31,850	32,441	32,130	—
Central U.P.	35.59	9,25,467	"	7,28,099	1,97,368	5,539	12,482	—
East U.P.	35.09	13,91,518	"	10,82,359	3,09,159	11,897	46,873	—
Bihar	36.28	12,69,348	"	9,79,651	2,89,697	22,042	15,394	—
West Bengal	33.38	31,866	"	26,730	5,136	44	62	—
Orissa	29.24	8,940	"	8,563	377	—	1,966	—
Madras	29.65	2,72,319	"	2,57,121	15,198	11	3,107	998
Madhya Pradesh	32.08	94,481	"	82,465	12,016	4,388	4,683	—
Rajasthan	30.24	42,662	"	39,502	3,160	1,055	8,637	—
TOTAL					12,12,203	80,064	1,27,738	998

Table 5—Regions where bagasse production is deficient

(tonnes)

Region	Bagasse prod. %Cane	Bagasse prod.	Bagasse requirement on 28%	Deficiency of bagasse	Existing consumption			Est. requirements of extra fuel to meet deficiency			Est. saving of fuel after meeting the deficiency		
					Coal	Wood	Furnace oil	Furnace oil	Wood	Coal	Coal	Wood	Furnace oil
Assam	27.49	16,106	16,405	299	188	1,186	—	—	239	—	188	947	—
Maharashtra	25.76	8,72,886	9,48,790	75,904	15,350	39,307	25,195	15,180	—	—	15,350	39,307	10,015
Gujarat	26.28	23,082	24,591	1,509	1,084	740	—	—	740	234	850	—	—
Andhra	27.22	3,85,494	3,96,540	11,046	4,339	12,310	—	—	8,836	—	4,339	3,474	—
Mysore	27.24	2,23,922	2,30,187	6,265	266	13,209	396	396	3,428	—	266	9,781	—
Kerala	26.19	31,729	33,922	2,193	—	—	—	—	—	—	—	—	—
								TOTAL ESTIMATED FOR 6 DEFICIT REGIONS			20,993	53,509	10,015

Table 6—Total estimated saving of fuel (All-India)

(tonnes)

Total cane crushed	2,47,83,938
Bagasse	12,12,203
Wood	1,94,251
Coal	1,00,957
Furnace oil	11,013

of centres in the high fibre areas, where saved bagasse from a number of nearby factories would become available. Where there is no use for the saved bagasse, steps taken for fuel saving may present problems of bagasse disposal. In the regions where other uses for bagasse have not been developed, the region as a whole could be made self-sufficient in respect of fuel by making the surplus bagasse of some of the factories available to those who need extra fuel. By this a sort of zonal self-sufficiency and elimination of coal and wood may be aimed at.

Efforts made for fuel and steam economy in sugar industry

Since its inception, the National Sugar Institute has been alive to the national need for steam and fuel economy in the sugar industry and has for several years been actively engaged on investigating the causes of excessive fuel consumption in sugar factories in India and in giving the necessary advice for improvement. A specific scheme, viz. the Fuel Economy Scheme was started in 1948 which carried out systematic survey with necessary instruments of 57 factories and drew up heat balances and based on those heat balances made specific recommendations. Several of the boiler furnaces were modified and other recommendations relating to improved steam generation and utilization given. It was subsequently realized that fuel and steam economy in the sugar factory is not isolated, but has directly to do with the entire working of the factory at all stages and particularly in the clarification and boiling houses. It was, therefore, considered necessary to start an integrated scheme, which would investigate all aspects of sugar production and equipment and give advice. At the instance of the Development Council for Sugar Industry an Extension Service to the Sugar Industry has been started at the National Sugar Institute in 1958 and so far preliminary survey of 41 factories and the final survey of 25 factories, have been completed. The fee is Rs 10,000.

Causes of excessive fuel consumption

According to the observations and investigations carried out by the Institute staff under the various advisory and extension services, the main causes for excessive fuel consumption in the sugar factories in India are as follows:

(i) Old and inefficient furnaces of inadequate combustion chambers and use of too much excess air

(ii) low pressure boilers with natural draught without super-heaters and without suitable heat recovery system, such as economizers and air pre-heaters

(iii) absence of semi-electrification and existence of inefficient steam driven units

(iv) production of too much exhaust due to inefficient steam units further aggravated by inadequate supply in some cases and local build-up of back pressures in others due to inadequate steam pipes

(v) extremely poor lay-out, exposed units without adequate lagging and insulation

(vi) absence of closed condensate systems resulting in loss of condensates and use of cold make-up water

(vii) over-crushing resulting in imbalance between crushing and processing operations

(viii) absolute lack of appreciation of fundamentals of combustion and heat conservation by operating personnel

(ix) complete absence of control instruments

(x) absence of steam economy measures in the boiling house, such as; vapour bleeding from evaporator and vapour cells for juice heating and sugar boiling in pans

(xi) bad maintenance of prime-movers and other steam using equipment and absence of necessary precautions to maintain the heating surfaces clean

(xii) in a number of cases poor design of equipment, particularly the evaporators, juice heaters and pans

(xiii) poor steam pressure and vacuum conditions

The above observations show that problems of fuel and steam economy in the Indian Sugar Industry are much more involved and complicated than in many other industries as it is very necessary to maintain a perfect balance between steam generations and utilization of steam for best results.

Measures to be taken for achieving fuel economy in sugar industry

The above are broadly the main causes of excessive for consumption in most of the Indian sugar factories. Those sugar factories in which surveys have been carried out, proper recommendations have been made for achieving possible efficiency. There are, however, still a number of factories, which are consuming extra fuel and in whom surveys have still to be carried out, in order to determine the specific action to be taken to make them efficient in respect of fuel. The main difficulties due to which no substantial progress is being made in achieving fuel efficiency are the difficulties of finance and foreign exchange. In factories where surveys have been made and necessary advice has been given the recommendations have not been implemented because either the factory has not been able to spare the necessary funds required for effecting major changes to boiler and processing equipment or the difficulty has been experienced in procuring machinery not available in the country from some other country. Due to limited facility of machinery manufacture in the country some of the essential equipments such as high pressure boilers, turbo alternators, electrical machinery, special fitting and valves and automatic high speed centrifugals, brass tubes, etc. have to be imported from abroad. Foreign exchange

requirement will have to be made available for such machinery for some time to come. In view of the above the following steps may be taken:

(1) Those factories who have completed technical surveys and finalized their programme for steam and fuel economy should be given financial assistance in the shape of loans in terms of easy repayment.

(2) Necessary foreign exchange requirements may be made available.

(3) The staff and equipment in Extension Service Scheme of the National Sugar Institute should be augmented so as to enable a larger number of factories to be taken up for survey than at present.

(4) Sugar factories should be asked to become efficient in respect of fuel within a stipulated period.

(5) The question of enlarging the field of service of the Extension Service Scheme may be examined in national interest.

(6) Assistance in respect of finance and foreign exchange should be given on a priority basis to those factories where the bagasse saved can be utilized for other purposes such as production of paper and bagasse boards.

(7) The efforts of economizing fuel consumption may be concentrated in those regions whose factories are found to be more inefficient.

(8) If the necessary steps are taken region-wise it will be possible to make a better assessment of the results achieved after certain period.

(9) Facilities will have to be provided for importing special boiler fittings and accessories, heat recovery units and control instruments. These will again need foreign exchange.

(10) The Institute had been giving instructions in special short courses entitled: (i) Milling plant operation and control (during 1943–49); (ii) Boiler and Fuel Control Course (from 1939 to 1949) but the courses had to be stopped due to poor response from the industry. The industry will have to be educated in regard to the need for providing proper training to their mill-house and boiler-house operatives.

(11) The Thacker Committee which recently went into the question of developing the Institute to meet the requirements of the industry has again recommended the starting of the following short courses:

(i) Certificate Course in Mill and Boiler Operation and Control

(ii) Certificate Course in Manufacturing Operations and Control

(12) The need for instrumentation and automation in sugar industry has also been realized by the National Sugar Institute several years ago and as a step in this direction an Instrument Section has already been started by the Institute. General training in instrumentation is being given to the students at the Institute and servicing of instruments received from the industry is also being done. But here again servicing is handicapped by having to obtain replacement parts from abroad necessitating foreign exchange.

(13) The Thacker Committee has also recommended the starting of a short course in Instrumentation and Automation. Those factories who have control instruments available with them can send their technicians to receive necessary training at the Institute. The facilities of staff and equipment in the Instrument Section of the Institute will have to be considerably enhanced.

(14) The Development Council for Sugar Industry, the Indian Sugar Mills Association and the National Sugar Institute should issue notes and leaflets from time to time to educate the industry regarding the need for fuel economy.

(15) Schemes for bagasse utilization should be developed side by side with fuel economy measures.

Price : Rs 6.50 Sh. 13 $ 2.00